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ORIGINAL ARTICLES.

Plant Migration across the Millstone Grit.

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I. Introduction.

THERE is one marked difference in the descriptions of the Carboniferous floral succession that have been furnished by Kidston and Potonié. Kidston emphasizes the existence of an abrupt change of flora at some point within the British Millstone Grit; while Potonié claims that he can demonstrate floral continuity right across the corresponding position in Upper Silesia (U.S. of Fig. 1, p. 58). Recent work by Renier seems to show that Potonié's results apply also in Belgium.

The present paper is based upon the hypothesis that both Kidston and Potonié are correct in their own fields. It suggests that temporary marine isolation induced a difference in the Carboniferous floral history of the two regions until the spreading deltas of the Millstone Grit provided a highway for plant migration. According to this proposition the plant-break of the Scottish Carboniferous is due to a replacement of the local flora by a southern competitor.

To render discussion possible it is necessary that the reader should have before him an outline of the Carboniferous classifications adopted in north-western Europe. First of all, however, I wish to acknowledge my indebtedness to Dr. J. Horne and Dr. G. W. Lee, who have kindly read my MS. and furnished many helpful criticisms.

II. Classification.

A certain amount of confusion obscures Carboniferous classification. This is partly due to the same names having been used by different authors with very different meanings. For instance, in our stratigraphical table it will be noticed that *Upper Carboniferous* has three different significations, while *Westphalian*[1] and *Carboniferous Limestone* have two apiece.

The strikingly tripartite lithology of England gave the first standard of comparison. Its application is a relatively simple matter in much of Ireland, England, and the Franco-Belgian coalfield. North and south of this wide belt, changes of facies introduce difficulties. The clear-water Carboniferous Limestone is in large measure replaced by terrigenous deposits, often with associated coal seams. Thus in the north of Ireland and in Scotland, on the one hand, and in the greater part of France and Western Germany, on the other, there is a much more monotonous lithological sequence than in the type district of England.

CARBONIFEROUS CLASSIFICATIONS COMPARED.

Munier-Chalmas and de Lapparent.		*Frech.*	*Potonié.*		*Kidston.*		*English Lithology.*	
Western Europe.		Germany.			Britain.			
Upper Carb.	Stephanian.	Otweiler Beds.		VI.			Coal Measures.	
Middle Carb.	Upper Westphalian.	Saarbrück Beds.	Upper Carboniferous.	V.	Radstockian.	Upper Carb.		
					Staffordian.			
				IV.	Westphalian.			
					Lanarkian.			
	Lower Westphalian.	Sudete Beds.		III.	Lower part of Millstone Grit and Scottish Carb. Limestone.	Lower Carb.	Millstone Grit.	
				II.			Pendleside Group.	Carboniferous Limestone.
Lower Carb.	Dinantian.		Lower Carb.	I.	Scottish Calciferous Sandstone.			

The connexion between these differences of facies and the physical geography of Carboniferous times is vital to our subject (*see* Section VII). In outline, it amounts to this: a northern and a southern land area were separated by the clear seas of the

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[1] W. W. Watts' substitution of *Yorkian* in place of Kidston's *Westphalian* is strongly to be recommended: "Carboniferous Nomenclature," GEOL. MAG., Vol. LIX, 1922, p. 238; see also R. Crookall, "On the Fossil Flora of the Bristol and Somerset Coalfield," GEOL. MAG., Vol. LXII, 1925, p. 393.

Carboniferous Limestone, and were subsequently in large measure connected by the deltaic spreads of the Millstone Grit and Coal Measures.

It will be understood that the establishment even of broad correlations between the Carboniferous deposits of the various areas of north-western Europe has presented very considerable difficulty. Two important steps in the comparison between Scotland and England may be cited as typical: Howell[1] in 1861, supported by the palaeontological knowledge of Salter, showed that the English Millstone Grit and Coal Measures can be recognized in Scotland: while Gunn,[2] in 1898, relying wholly upon stratigraphy, demonstrated that the "Carboniferous Limestone" Series of Scotland corresponds with no more than the uppermost part of the Carboniferous Limestone Series of England, which latter is mainly represented in Scotland by the Calciferous Sandstone. In passing, it is well to remind readers that the "Carboniferous Limestone" series of Scotland only contains a small proportion of limestone; on the average, the aggregate thickness of its separate limestone bands is about twice that of its coal-seams, and is far less than that of its associated terrigenous deposits—sandstones, shales, and fire-clays.

Within the last thirty years, England has lost something of its early pre-eminence in Carboniferous classification. Need arose for a comprehensive palaeontological treatment of the subject, and Munier-Chalmas and de Lapparent[3] adopted Belgium as type-district for north-western Europe—supplementing its deficiencies in regard to the uppermost division by recourse to the Central Plateau of France. Stephanian, it may be remarked, takes its name from St. Étienne, with the Latin *Stephanus* replacing the French *Étienne.*

To begin with, so far as Belgium was concerned, the separation of Dinantian and Lower Westphalian depended upon marine faunas, while the zoning of the Upper Westphalian and Stephanian was based upon land floras. In Upper Silesia, there are sufficient marine beds in the lower part of the Carboniferous sequence to render comparison possible with the Dinantian and Lower Westphalian of Belgium; while interstratified plant beds give a fairly complete floral record. On these grounds, it is accepted by continental geologists that

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[1] H. H. Howell and J. W. Salter in "The Geology of the Neighbourhood of Edinburgh," *Mem. Geol. Surv.*, 1861, pp. 103, 105, 144.

[2] W. Gunn, "Notes on the Correlation of the Lower Carboniferous Rocks of England and Scotland," *Trans. Geol. Soc. Edin.*, vol. vii, 1899, p. 361; and GEOL. MAG., 1898, p. 342. Gunn points out that all except the lowest division of the Scottish "Carboniferous Limestone" Series lies above the Yoredale Beds as defined by Phillips. "The term Yoredale was by the Geological Survey extended so as to include these beds [in Wensleydale, Yorkshire], but they were classed with the Millstone Grit by Phillips, though sometimes he seems to have included a portion of them in his Yoredale Series."

[3] Munier-Chalmas and A. de Lapparent: "Note sur le nomenclature des terrains sedimentaires," *Bull. Soc. Géol. Fr.*, 3rd ser., vol. xxi, 1893, p. 447; see also A. de Lapparent, *Géologie,* 5th ed., vol. ii, 1906, p. 889.

Potonié's[1] Flora I belongs to Munier-Chalmas and de Lapparent's Dinantian, and his Floras II and III to their Lower Westphalian (also called Sudete Beds by Frech,[2] after the Sudete Mountains of the Upper Silesian region). Potonié's Flora IV is admittedly the same as the basal flora (Châtelet) of the Upper Westphalian.

It is with these positions that the present paper deals, and it is important to note how favourably Munier-Chalmas and de Lapparent's work is viewed by Belgian geologists of to-day. Renier[3] states that their separation of Dinantian and Lower Westphalian is palaeontologically convenient. It is marked by the disappearance of *Productus giganteus* at the top of the Dinantian, and by the incoming of *Goniatites diadema* (called *Glyphioceras striolatum* in de Lapparent and Haug's Textbooks) at the base of the Westphalian.

Our stratigraphical table suggests an *approximate* comparison between Continental and British classifications. The position is as follows:—

(1) When, in 1896, Potonié published his account of the six German (including Upper Silesian) Carboniferous floras, he correlated them with Kidston's divisions (to which the titles Lanarkian, etc., had not yet been attached) as follows:—I, Calciferous Sandstone; II, Scottish Carboniferous Limestone; III, Millstone Grit; IV, Kidston's Lower and Middle Coal Measures (afterwards called by Kidston upper part of Lanarkian and Westphalian respectively); V, Kidston's Transition Coal Measures (Staffordian); VI, Kidston's Upper Coal Measures (Radstockian).

(2) The grouping of Potonié's Flora II with Kidston's Scottish Carboniferous Limestone flora is roughly paralleled in Renier's writings where he quotes (op. cit., p. 250) Hind, Cornet, and Purves as having proved the equivalence of the Chokier Ampélites of Belgium and the Pendleside Group of Mid-Britain. The Chokier Ampélites (black shales with black limestone nodules) form the bottom half of Munier-Chalmas and de Lapparent's Lower Westphalian.

(3) The earlier part of Flora III has marine associations in Upper Silesia which prove it to be contemporaneous with a portion of the Belgian Ampélites. This fact is expressed in our table by showing the British Millstone Grit as commencing a little later than Flora III. Potonié, it will be remembered, placed his Flora III as the approximate time-equivalent of our Millstone Grit.

(4) Another adjustment affects the upper portion of the Millstone Grit. Flora III, according to Potonié, is intermediate in character between Flora II and Flora IV, and contains an admixture of their distinctive species. When Potonié suggested his time-correlation between Flora III and the British Millstone Grit, he probably anticipated the eventual discovery of Flora III by British collectors. The British Millstone Grit is comparatively barren, but Kidston's continued researches have shown that it contains nothing at all closely comparable with Potonié's intermediate Flora III. Instead, there is an abrupt floral change at a particular level in the Millstone Grit, where the Scottish Carboniferous Limestone flora suddenly gives way to the Lanarkian. In his comparisons, Potonié grouped the Lanarkian with his Flora IV; and, in our table, we now place the upper part of the British Millstone Grit (the part above the plant break) opposite the lower part of Potonié's Flora IV. It will be some time before really close correlations can be established.

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[1] H. Potonié: "Die floristische Gliederung des deutschen Carbon und Perm," *König. Preuss. geol. Landesanstalt*, N.F., heft 21, 1896, pp. 14, 57.

[2] F. Frech: "Lethaea geognostica," Band 2, Lief. 2, 1899, Table xxii, p. 354.

[3] A. Renier, "Les Gisements houillers de la Belgique,"—chap. viii, Rélations internationales de stratigraphie, *Annales des Mines de Belgique*, tome xx, 1919, p. 250.

(5) Another minor adjustment of Potonié's correlations may be mentioned, although it does not affect the subject of the present paper. Renier (op. cit., p. 253) quotes the agreement of Zeiller, Arber, and Gothan that Kidston's Radstockian is better classed as topmost Westphalian (Munier-Chalmas and de Lapparent) than Stephanian (Potonié's Flora VI). We have adopted this suggestion.[1]

It is necessary at this stage to enter into a little more detail regarding the plant break in the British Carboniferous.

III. FLORAL BREAK IN BRITAIN.

The British Carboniferous floral break has been established by Kidston, and the more critical part of the zonal collecting which he directed in this connexion was carried out by D. Tait, of the Scottish Geological Survey.

Kidston[2] has recently summarized his investigations (*Fossil Plants*, p. 10) as follows :—

" It has been found from the examination of the fish fauna and the fossil plants from the Roslin Sandstone Group (' Millstone Grit ') around the Midlothian Basin [Scotland] that the Lower Carboniferous forms extend up into the Roslin Sandstone for about one-third of its thickness, and that the upper two-thirds contains only Upper Carboniferous forms, with the exception of one or perhaps two doubtful species which extend a short distance higher up.[3] A similar palaeontological break has also been observed in the so-called ' Millstone Grit ' of Lanarkshire and Ayrshire [Scotland], and part at least of the ' Millstone Grit ' of the Titterstone Clee Hill coalfield [England] has been shown from plant evidence to be of Lower Carboniferous age.[4]

" Another most interesting section, showing the sudden disappearance of the Lower Carboniferous plants and the equally sudden appearance of Upper Carboniferous species, occurs in the Congleton-Leek district of North Staffordshire [England].

" In this area, in the so-called ' Millstone Grit ' rocks, the Upper Carboniferous plants extend down to a depth of about 50 feet below the ' Fifth Grit ', then succeeds a distance of about 60 feet of barren rock, when suddenly a typical Lower Carboniferous flora appears . . .

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[1] R. Crookall in " The Fossil Flora of the Bristol and Somerset Coalfield " : GEOL. MAG., Vol. LXII, 1925, p. 395, adopts Kidston's view that the Radstockian is the lowest part of the Stephanian. He, too, quotes Zeiller as approving. The difference is evidently of minor significance.

[2] R. Kidston, " Fossil Plants of the Carboniferous Rocks of Great Britain " : *Mem. Geol. Surv.*, 1923, p. 14 ; see also " On the Various Divisions of British Carboniferous Rocks as determined by their Fossil Flora " : *Proc. Roy. Phys. Soc. Edin.*, vol. xii, 1894, p. 183.

[3] " Summary of Progress for 1903 " : *Mem. Geol. Surv.*, 1904, p. 118. " The Geology of the Neighbourhood of Edinburgh " : *Mem. Geol. Surv. Scotland*, 2nd ed., 1910, p. 6.

[4] R. Kidston, T. C. Cantrill, and E. E. L. Dixon, " The Forest of Wyre and the Titterstone Clee Hill Coal Fields " : *Trans. Roy. Soc. Edin.*, vol. li, 1917, p. 1066.

"The sudden disappearance of one flora and the equally sudden appearance of another is one of the most remarkable facts of Vegetable Palaeontology, and for which I can offer no satisfactory explanation."

Kidston points out that there is no change of lithology correlated with the change of flora, so that it does not look as if changing "physical conditions" (presumably he means climate and elevation) had necessitated a plant migration—and the mere fact that the earlier and later floras were equally prone to furnish coal seams through luxuriant growth of maritime swamps strongly supports this contention. He further remarks that it is difficult to conceive of a hiatus in the British Carboniferous stratigraphical record sufficiently important to correspond with the observed hiatus in the plant succession, since such a hiatus might be expected to betray itself by unconformity. At the same time, he quotes with approval his deduction of 1893 (published 1894) that the plant-break indicates a very considerable lapse of time.

I venture to suggest that the difficulties of accounting for the plant-break by invoking a hiatus in the stratigraphical record are even greater than Kidston has indicated :—

(1) The Scottish Carboniferous sediments accumulated in a region that was subsiding very unevenly. This is shown by their rapid local variations in thickness combined with their constantly recurring land-surfaces (attested by root-beds). The tabulated measurements furnish an extreme example of this phenomenon.[1]

		Two districts near Patna, Ayrshire, separated by only 2 miles of unproved ground.		North-west side of Mid-Lothian coal-field, quoted for comparison from index of Sheet 32, *Geol. Surv. one-inch Map* (1910).
		Ft.	Ft.	Ft.
	Millstone Grit.	120	390	775
Scottish Carb. Lst. Series.	Upper Limestone Group.	40	700	1050
	Limestone Coal Group.	100	260	1050
	Lower Limestone Group.	30	70	700

(2) It is almost incredible, under such circumstances, that an important hiatus could occur in the sequence without a striking unconformity. Admittedly, local unconformities have been detected in connexion with the Scottish Millstone Grit, as for instance by C. H. Dinham, near Strathaven, Lanarkshire ;[2] but the essential conformity of the group is admitted by most observers

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[1] V. A. Eyles and A. G. MacGregor in "Summary of Progress for 1924" : *Mem. Geol. Surv.*, 1925, pp. 91–4.

[2] This unconformity brings Millstone Grit about a quarter way down the Upper Limestone Group which immediately underlies it (see C. H. Dinham in "Econ. Geol. Central Coalfield Scot., Area IX" : *Mem. Geol. Surv*, 1921, p. 78, and pl. v). In Ayrshire, comparable phenomena have been met with (see G. V. Wilson in "Sum. Prog. Geol. Surv. for 1913" : *Mem. Geol. Surv.*, 1914, p 59). Outside of Scotland, unconformable relations have also been proved in South Wales (see O. T. Jones in "The Geology of the South Wales Coalfield, xi, Haverfordwest" : *Mem. Geol. Surv.*, 1914, p. 151 ; also F. Dixon and T. F. Sibly, "The Carboniferous Limestone Series on the South-Eastern Margin of the South Wales Coalfield" : *Quart. Journ. Geol. Soc.*, vol. lxxiii, 1918 for 1917, p. 157).

who view the matter from the purely stratigraphical standpoint. The opportunity for judging is excellent, since widely exploited coal-bearing groups occur both above and below the Millstone Grit. Moreover, the parallelism is not merely lithological. Kidston's demonstration that the same plant-break occurs within the Millstone Grit of Scotland and of Staffordshire in the centre of England, is surely extremely significant. It emphasizes the importance of the next consideration in our list.

(3) The plant-break occurs *within* the Millstone Grit, and is not marked by any change of aggregate lithology (the sequence is a varied one of grits, fireclays, and shales). This suggests essential continuity of deposition.

(4) If, on the other hand, Kidston is correct in supposing the plant-break indicates a hiatus in the geological record, during which the flora had time to change *completely* by evolution, etc., *in situ*, one would expect a comparable change in the marine fauna at the same position. No such change exists—though we shall see presently (Section VI) the estuarine fishes of the period behave in just the same manner as the plants. Accordingly, it seems that some type of migration-hypothesis is required to account for the sudden change of flora. The stratigraphical record scarcely admits of migration impelled by modification of local environment. On the other hand, it encourages us to look abroad.[1] It conjures up a picture of migration permitted by readjusted frontiers of land and sea. The change of flora occurred in Millstone Grit times when deltas spread out from the lands of western Europe, more or less replacing the waters of long-established seas. The deltas of the old Scottish coast pushed southwards across England. Let us follow them southwards. We have already suggested that there lay the source of Kidston's Upper Carboniferous flora.

IV. Floral Continuity in Upper Silesia.

Potonié (*Die floristische Gliederung*, p. 3) confirms D. Stur's contention that there is floral continuity between his (Potonié's) Floras I and II. He then continues (free translation) :—

"At the same time the flora [II and earlier part of III] of the Waldenburg and Ostrau Beds is continuously linked, through that of overlying younger horizons, with the flora [IV] of the Karwin and Schatzlar Beds. In Upper Silesia this relation has long been suspected. The Saddle-Seams horizon preserves a veritable mixed flora [later part of III], characterized by a coexistence of floras proper to the underlying and overlying positions. In this connexion, E. Weiss already said, in 1879 : 'It looks as if Upper Silesia will furnish proof of a gradual development from the one flora [II] to the other [IV]. At the present time, it is certainly impossible to draw a satisfactory boundary between the two.' I myself [Potonié], after a year's study of the Upper Silesian flora, am compelled to say that a gradual passage does certainly lead from the lower to the upper part of the Carboniferous system."

If we accept Potonié's conclusion, it follows that there existed in the south a land where Kidston's Lower Carboniferous flora was replaced gradually by his Upper Carboniferous flora.

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[1] B. N. Peach has expressed very much the same idea when he wrote "As the rocks afford no sign of a physical break in the region under consideration, some great physical change must have taken place outside it to account for the almost complete replacement of the flora and fish fauna by others. Change of climate alone seems powerless to bring about so sudden a revulsion." *Proc. Roy. Phys. Soc. Edin.*, vol. xix, 1916, p. 257.

We shall now see that the facts that have accumulated in Belgium seem to fall in line with Potonié's reading of the Upper Silesian record.

V. FLORAL CONTINUITY IN BELGIUM.

Renier's writings provide the readiest source of information in regard to Belgian Carboniferous problems. At the present time,[1] he adopts the Munier-Chalmas and de Lapparent classification, with Chokier Ampélites and Andenne Grits constituting the Lower Westphalian, and the productive Châtelet Group furnishing the bottom division of the Upper Westphalian. In his floral discussions he makes great use of both Kidston's and Potonié's researches. Rightly or wrongly he does not seem to recognize anything comparable with the British plant break.

In reading the next two paragraphs it must be understood that, as lately as 1908, Renier excluded the Chokier Ampélites from the Westphalian.

In 1906,[2] he described the Chokier flora, and compared it with Kidston's Scottish Carboniferous Limestone flora, and also with Potonié's Floras I and II. Besides pre-Westphalian species (using pre-Westphalian in the sense of pre-Andenne) he noted "a certain number of well-known Westphalian species, such as *Sphenopteris Essinghi, S. Goepperti, Neuropteris Schlehani, N. obliqua, Pecopteris dentata, P. pennaeformis, Alethopteris decurrens, Lepidodendron aculeatum, L. rodeanum*, etc." His comment is that, though it may be disconcerting to find Westphalian species along with a majority of Culm forms, after all such an experience is a commonplace in palaeobotany.

In 1908,[3] he published an account of the flora of the lower part of the Andenne Group. He notes its transitional type, with some ancient forms as *Asterocalamites scrobiculatus, Sphenophyllum tenerrimum*, but with, on the whole, a strong Westphalian (meaning post-Chokier) facies. The Andenne flora, together with the earlier part of the succeeding Châtelet flora, he paralleled with Kidston's Lanarkian and Potonié's Flora II.

Here, let us turn from land plants to estuarine fish. In this case, it is only possible to marshal Scottish evidence.

VI. FISH-BREAK IN SCOTLAND.

No change occurs in the open sea fauna of the British Carboniferous that is at all comparable with Kidston's plant-break. This remark applies to fish, just as much as to invertebrates. On the other hand, R. H. Traquair, so long ago as 1884,[1] recognized that the *estuarine* fishes of Britain are divisible into two distinct series, an older and a younger. His evidence is mainly derived from Scotland. It is not quite so full as that obtained by Kidston in regard to plants, but its import may be gathered from the following quotation :—[2]

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[1] A. Renier, "Stratigraphie du Westphalien": *Congrès Géol. Internat.*, 1922, livret guide, excursion C 4; see also p. 60 of present paper.

[2] A. Renier, "La Flore du terrain houiller sans houille (H 1*a*) dans le bassin du couchant de Mons": *Ann. Soc. Géol. Belg.*, vol. xxxiii, 1906, pp. 169, 170.

[3] A. Renier, "Note sur la flore de l'assise moyenne, H 1*b* de l'étage inférieur du terrain houiller": *Ann. Soc. Géol. Belg.*, vol. xxxv, 1908, pp. 122, 123.

"We have in the estuarine beds of the Lower Carboniferous series of the central valley of Scotland a fish fauna of which many of the species persist through thousands of feet of strata, and must therefore have lived for a very long time without change in their specific characters. Then, after the Millstone Grit, poor in fish remains, is passed, we come to a new fauna, from which nearly all the Lower Carboniferous species, and with them also a number of genera, have disappeared, their place being taken by an Upper Carboniferous assemblage, which in its main features is characteristic not only of the Coal Measures of Scotland but of the Lower and Middle Coal Measures of England, extending into the Transition series of the latter country.

"Why this sweeping change took place about the time of the Millstone Grit we do not know."

Surely, the geography of the time is significant. Up till then the Scottish rivers discharged directly into the Carboniferous Limestone sea. Thereafter, they became intermittently tributary to the general river system of Western Europe. Their doors were thus thrown open to migration from the south.

The main purpose of our communication is now obtained. We have shown that two very striking features of British Carboniferous palaeontology can be brought into correlation with well-known geographical conditions pertaining to the epoch of the Millstone Grit. We shall conclude with a brief summary of some of the outstanding events of European history during the latter part of Palaeozoic times. It will then appear that the Millstone Grit occupies a very characteristic position in the story as a whole.

VII. HERCYNIAN MOUNTAINS OF EUROPE.

Students of Eduard Suess, Marcel Bertrand, and Émile Haug, to mention but three of the great authors who enable us to think internationally, will recognize the source of most of the ideas that follow. In another place, I may attempt to justify the selection that has been made ; but, for the present, this is unnecessary.[3]

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[1] H. H. Howell in 1861 made use of fish in support of his determination of English Coal Measures in Scotland.

[2] R. H. Traquair, "Distribution of Fossil Fish Remains in the Carboniferous of the Edinburgh District": *Trans. Roy. Soc. Edin.*, vol. xl, 1903, p. 707.

[3] It is only right to note that Hercynian is used in Bertrand's sense familiar to British readers, and not in that originally given to it by L. von Buch, see E. Suess, *Face of the Earth* (Sollas edition), vol. iv, p. 1.

(1) During Carboniferous times the great Hercynian Chain of Western Europe rose on the south side of the frontal line indicated on the figure. It eventually occupied the whole of the country between this frontal line and that of the later Alpine chains—as well as extending far to the south.

(2) During Devonian times, the frontal line of the future Hercynian chain marked the approximate southern coast of the continent of Eureria.[1] North of this line, for some distance eastwards into Russia, most of the sedimentary deposits of the time are non-marine, merging into lagunal in the Baltic provinces. South of the line, marine conditions very generally prevail. Devonshire, Belgium, and the Rhenish uplands give excellent exposures of deltas and off-shore deposits, discharged from the Eurerian continent into the southern sea.

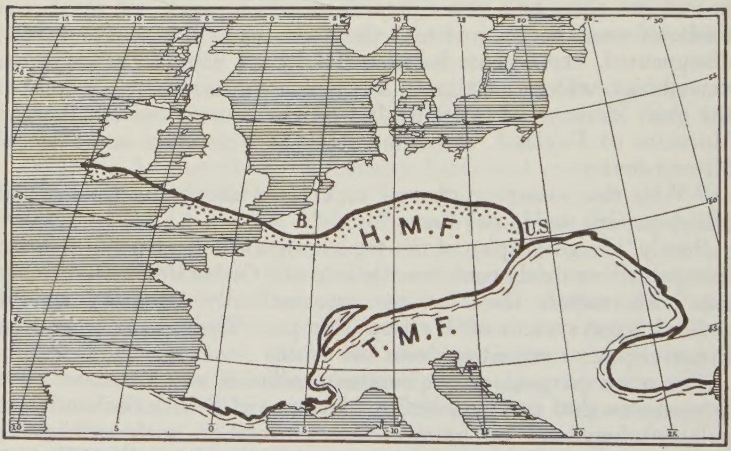

FIG. 1.—H.M.F. = Hercynian Mountain Front. T.M.F. = Tertiary Mountain Front. B. = Belgium. U.S. = Upper Silesia. Adapted from E. Suess.

(3) The main marine transgression of Devonian times took place in the middle of the period. The Givetian sea advanced westwards from eastern Russia far into the Baltic provinces, and in Belgium it passed northwards across the "Condroz line" to invade the Hercynian foreland. De Lapparent (*Géologie*, 5th ed., pp. 860–1, and fig. 336; he is quoting from Gürich) argues that the Russian sea did not establish direct connexion across the North-German Plain with the Belgian-Polish sea, but left a Mid-European peninsula even at this period of maximum transgression. The two seas, he states, belong to distinct zoological provinces.

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[1] E. Suess uses the name Eria borrowed from Lake Erie—*Face of the Earth*, vol. iv, p. 59. For our purpose it is convenient to call the European part of the Erian continent Eureria, as we can then continue the use of the name into post-Devonian times.

(4) During Upper Devonian times, the Mid-European peninsula of Givetian times lost its individuality owing to general marine regression. On the other hand, during Dinantian times, it may well have been swamped by marine transgression, which then occurred to a much greater extent, except perhaps in the Baltic provinces, than at any time during the Devonian.[1]

(5) The Dinantian transgression drove northwards the Eurerian deltas, forcing them to retreat from Devonshire to Scotland. The southern belt of the continent became submerged beneath the clear waters of an open sea, diversified by islets too small to furnish deltas of their own. The site of the Carboniferous Limestone sea occupies most of Southern Britain, and is easily recognizable in Belgium. It is lost to view beneath the Mesozoic accumulations of the North German Plain, but is revealed again near Cracow, east of the Upper Silesian Coalfield. It is to the Carboniferous Limestone sea, and its continuation into Lower Westphalian times, that we must look for the isolation of the flora and fish-fauna of the Eurerian continent.

(6) Though the deltas and terrigenous deposits of the Eurerian continent were displaced northwards in Dinantian times, their position was at once seized upon by sands and muds derived from the south. The Hercynian Chain had already grown to such dimensions that it could provide deltas of its own. In fact, it stood as an island-festoon facing the northern continent.

(7) Much of the mud derived from the island-festoon during Dinantian times was black with carbonaceous material, and its associated fauna was of a rather special type, characterized by ammonoids, *Posidonomya*, *Aviculopecten*, Radiolaria, etc. It is sometimes argued that this peculiar fauna indicates a considerable depth (Haug and others),[2] but the close association of Posidonomya shales with greywackes (very reminiscent of the earlier association of graptolite shales with greywackes during Ordovician and Silurian times)[3] makes this view scarcely tenable. It is here suggested that

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[1] De Lapparent (*Géologie*, 5th ed., fig. 376, p. 905) extends the peninsula in Dinantian times; but this seems illogical considering the pan-European character of the Dinantian fauna.

[2] E. E. L. Dixon has very definitely combated the depth-hypothesis in its application to certain radiolarian cherts of South Wales, in "The Carboniferous Succession in Gower (Glamorganshire)": *Quart. Journ. Geol. Soc.*, vol. lxvii, 1911, p. 519. On the other hand, L. Cayeux, in a preliminary announcement, says that the many radiolarian cherts he has examined (horizons not stated) are clearly deep-sea deposits on account of their freedom from quartz, sponge-spicules, and foraminifera; see "La question des jaspes à radiolaires au point de vue bathymétrique": *C.R. Comm. Géol. Soc. Fr.*, Janv., 1924, p. 11.

[3] W. B. R. King, in "The Upper Ordovician Rocks of the South-Western Berwyn Hills": *Quart. Journ. Geol. Soc.*, vol. lxxix, 1923, p. 494, has already developed this comparison with special reference to Dixon's work. In a similar connexion, J. E. Marr, in "Conditions of Deposition of the Stockdale Shales of the Lake District": *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, remarks "Professor Charles Lapworth, however—see his notes, in a paper by Professor J. Walther, 'Ueber die Lebensweise Fossiler Meeresthiere,' *Zeitschr. Deutsch. Geol. Gessellsch.*, vol. xlix, 1897, p. 209—maintained that

the chemistry, rather than the depth of the water, was the main factor in determining the faunal assemblage. How greatly carbonaceous material may affect the composition of sea water is shown by J. Murray and R. Irvine's[1] researches on the series of reactions that follow the decomposition of sulphates with the production of sulphides and the liberation of carbon dioxide. Leaving such questions on one side, readers will at any rate admit that the black muds of the south came from the south, and not from across the clear limestone sea that spread to the north.

(8) At the close of the Dinantian, one of the greatest folding episodes of the Hercynian occurred. It was then that the foundations of the Lower Silesian, Saar and Vosges coalfields yielded freely for the last time. Thereafter, they remained comparatively rigid and moved up or down with little crumpling. Part of the more peripheral belt, including Upper Silesia and Devonshire, was also affected ; but this outer district was only involved to a minor extent, and it took part in later corrugations.

(9) The post-Dinantian movement was succeeded by a great extension of the black southern muds into Belgium, England, and Ireland (Ampèlites and Pendlesides).

(10) Then followed the regional upheaval, and delay of subsidence, that carried the interlacing deltas of Millstone Grit across the erstwhile site of the Carboniferous Limestone sea. Eureria established intermittent contact with the Hercynian Chain, and the plants and fishes of the south found themselves faced with old worlds to conquer.

(11) During Westphalian times any Coal Measures that accumulated in the Hercynian region were of inland formation, e.g. Saar basin. On the other hand, Coal Measures, occupying what had been the site of the Carboniferous Limestone sea, formed approximately at sea-level and were subject, more particularly in their earlier stages, to periodical marine incursions (e.g., Westphalia and Britain). The continuity of the geographical evolution of Carboniferous time is further shown by the fact that the Westphalian Coal Measures of Scotland contain fewer marine intercalations than those of northern and central England.

graptolites were pseudoplanktonic, being attached to floating algae of Sargasso type, and that the colouring matter of the deposits was due to carbon derived from the 'weed', although he adduced no analyses in support of this view. Incidentally, he stated that these graptolite-bearing beds were deposited in deep and shallow water alike, the essential conditions being quietness of the waters". Marr's paper includes a wealth of his own observations in regard to the geological importance of chemico-biological environment.

[1] J. Murray and R. Irvine, "On the Chemical Changes which take place in the Composition of the Sea-Water associated with Blue Muds on the Floor of the Ocean": *Trans Roy. Soc. Edin.*, vol. xxvii, 1893, p. 496. See also the same authors' suggestion that the reaction between the sulphides and clay may render silica available for animal consumption: "On Silica and the Siliceous Remains of Organisms in Modern Seas": *Proc. Roy. Soc. Edin.*, vol. xviii, 1891, p. 248. Geologists will find useful references of this kind in L. W. Collet's *Les Dépôts Marins*, Paris, 1908.

(12) The Westphalian sea of Western Europe was zoologically distinct from its contemporary of Russia. Accordingly, I suggest that the old Mid-European peninsula, of Givetian geography, reasserted itself, and now functioned as an isthmus connecting Eureria with the Hercynian Chain. If so, the Westphalian sea of the west opened to the west and not to the east as is commonly suggested.[1]

(13) After the close of Westphalian times came the last great folding movement of the Hercynian Chain, the one responsible for the main structure of the northern marginal belt. A concomitant, or subsequent, general upheaval of the foreland region led the way to the familiar post-Carboniferous unconformity of Britain. In the heart of the mountain region, the inland development of the Carboniferous was greatly extended in Stephanian times, and continued without interruption into the Permian.

A New Miocene Echinoid from N.W. Peru.

By A. G. Brighton, M.A., F.G.S., Sedgwick Museum, Cambridge.

(PLATES III–V.)

MATERIAL.—The six more or less complete specimens and twelve fragments to be described are preserved in a coarse ferruginous sandstone. They were collected by Messrs. C. Barrington Brown and R. A. Baldry, who supply the following particulars of horizon and locality, and to whom the author is indebted for the opportunity of describing this interesting echinoid.

Family SCUTELLIDAE L. Agassiz.

Genus Encope L. Agassiz, 1840 (1,[2] pp. 6, 17).

E. peruviana sp.nov.

Diagnosis.—An *Encope* of medium size, with adapical surface flat towards the ambitus, very tumid adapically. Greatest height of corona one-fifth of the anterio-posterior diameter, which is slightly greater than the transverse diameter. Ambulacral notches narrow, oval, moderately deep. Lunule quadrangular, of medium size. Petals broad, moderately long, equal in length. Buccal cavity small.

Horizon.—"The specimens were all collected from one horizon near the top of, or just above, the Upper Zorritos Formation as defined by Spieker (15). From a detailed study of the Mollusca he deduces a late Burdigalian age for these beds (loc. cit., pp. 29–30)." [R.A.B.]

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[1] De Lapparent draws attention to a contested determination of *Spirifer mosquensis* from the east side of the Upper Silesian coalfield, west of Cracow—*Géologie*, 5th ed., p. 940.

[2] These figures refer to list of works at end of paper.

" The Zorritos Formation, a thick series of sandstones and clays of presumably Miocene age, lies unconformably upon Lower Tertiary Beds—the Lobitos and Negritos Formations of T. O. Bosworth (14)—and the older rocks of the Amotape Mountains. The base of this series outcrops along a fairly straight line from near Punta Sal on the Peruvian Coast in an east-north-easterly direction to La Capitana, a hamlet on the Tumbez River, where it rests on the Amotape Rocks. North of this line, only these Miocene beds are found. This unconformity was determined and mapped by us in 1924, and does not appear to have been hitherto recognized.

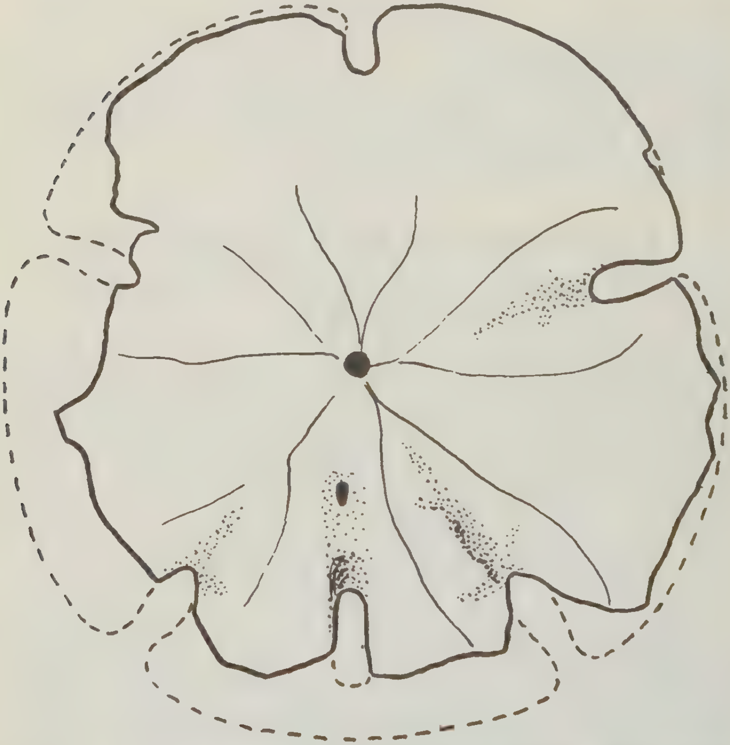


FIG. 1.—*E. peruviana* sp.nov. × 1. Specimen D, holotype. Adoral surface. The anterior portion is covered by matrix.

" The horizon at which the specimens of *Encope* were found, is estimated as about 2,500 feet above this base." [C.B.B.]

Locality.—Near Corrales, Tumbez, N.W. Peru.

Description.—The following description is based on the holotype, specimen D, except when otherwise stated.

Size and Shape.—Adoral surface flat; adapical surface flat towards the ambitus, but very tumid adapically. The corona may thus be regarded as made up of an inflated cylindrical portion, rising from an outer, rim-like margin, the edge of which forms the ambitus. The dimensions in mm. of the six complete specimens (A–F), and of four others (G, H, J, and K) are :—

Specimen.	*Antero-posterior Diameter.*	*Transverse Diameter.*	*Maximum Height.*
A.	85·5	84 (98%)	21·5 (25%)
B.	90·0	—	24·3 (27%)
C.	93·0	—	28·5 (31%)
D.	98·0	95 (97%)	20·7 (21%)
E.	105·0	94 (90%)	21·0 (20%)
F.	110·5	106 (96%)	26·6 (24%)
G.	93	—	18·0 (19%)
H.	—	92	20·0 (? 22%)
J.	89	—	19·0 (22%)
K.	98	—	20 (20%)

Notes.—(1) The peristome is seen to be central in specimen A; the transverse diameters of the remaining specimens, in all of which the posterior margin is missing, have therefore been calculated as twice the distance between the anterior margin and the centre of the peristome. (2) The values for the transverse diameter and the height are given also as percentages of the antero-posterior diameter.

The ratio of the height to the antero-posterior diameter is slightly greater than 1 : 5 in the holotype, and almost reaches the value 1 : 3 in specimen C. The ratio of the transverse diameter to the antero-posterior diameter also varies, but the transverse diameter is the slightly smaller of the two. The inflated cylindrical portion of the test is highest anteriorly, and markedly depressed centrally. On the raised central region of the corona, the adradial tracts are slightly depressed; while the perradial tracts of the petals, and the interradial tracts of the paired interambulacra (but not that of the unpaired interambulacrum) are inflated. The height of the corona near the margin is 2 mm.

Ambital outline approximately circular. Ambulacral notches open, oval, contracting towards the ambitus. The anterior notch is the smallest, the posterior pair the largest. Interambulacral lunule quadrangular, widening towards the ambitus; its anterior margin slopes adorally from the adapical surface at an angle of 45° to the adoral surface.

Adoral surface flat. Ambulacral furrows narrow. Shallow branching depressions extend from the ambulacral notches towards the peristome without reaching it. A further shallow depression, deepening towards the lunule, extends from the lunule half-way towards the peristome.

Peristome.—Circular, small, 3 mm. in diameter. In specimen A, the peristome is seen to be central.

Periproct.—Small, elongate, quadrangular; between the peristome and the lunule, and slightly nearer the lunule; within the depression running from the lunule towards the peristome, but at its anterior end. The periproct is often not situated on the antero-posterior plane of symmetry of the test.

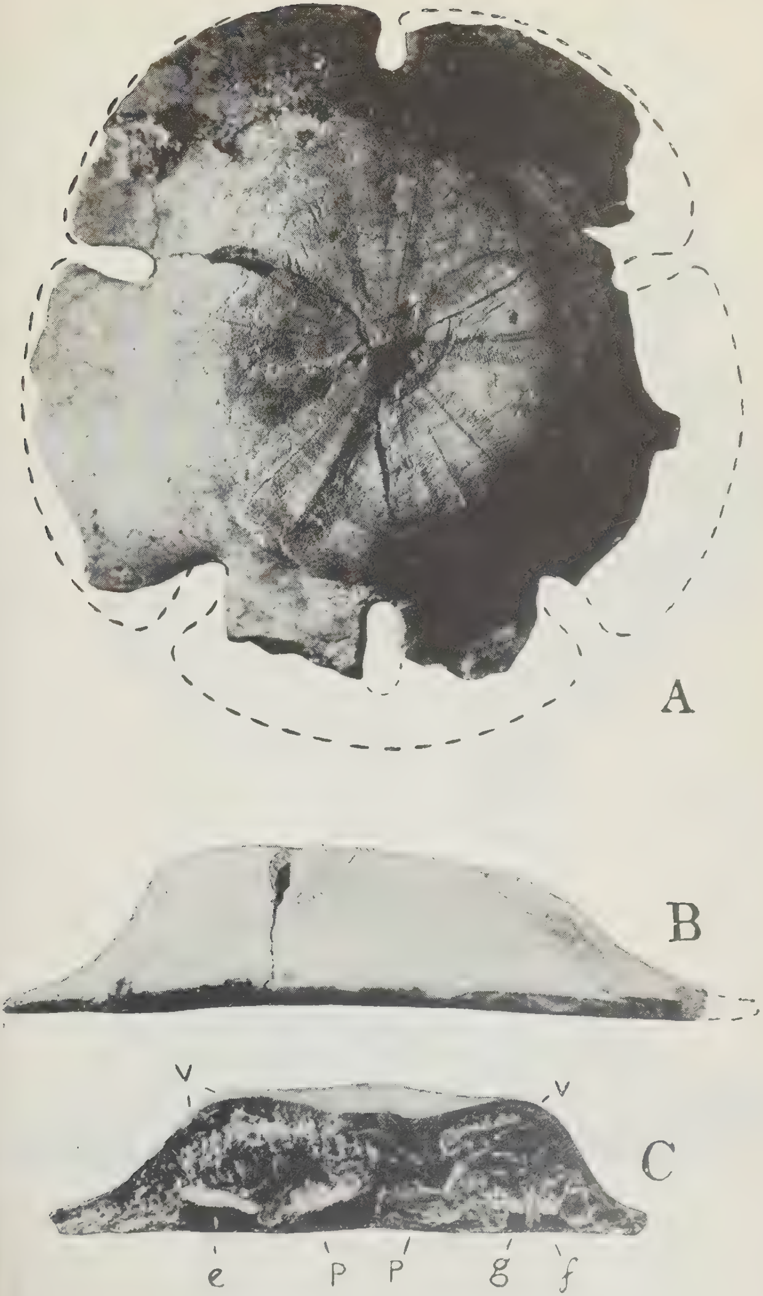
Apical Disc.—Central; five genital pores situated outside the stellate madreporic region, and five smaller ocular pores. In specimen J, each ocular plate seen protudes slightly above the level of the apical disc, and partly overhangs its ocular pore.

Ambulacra.—Petals long, equal; extending three-quarters or four-fifths of the distance between the ocular pores and the inner margin of the notches; the greatest width of each petal situated much nearer the ambital end than the adapical, and equal to two-fifths of its length. Poriferous zones slightly wider than the interporiferous areas.

Ornamentation.—The whole of the corona is covered by small, crowded, imperforate and scrobiculate tubercles, which are larger and less crowded within the lunule and notches, at the ambitus, and on the whole of the adoral surface except in the vicinity of the ambulacral furrows.

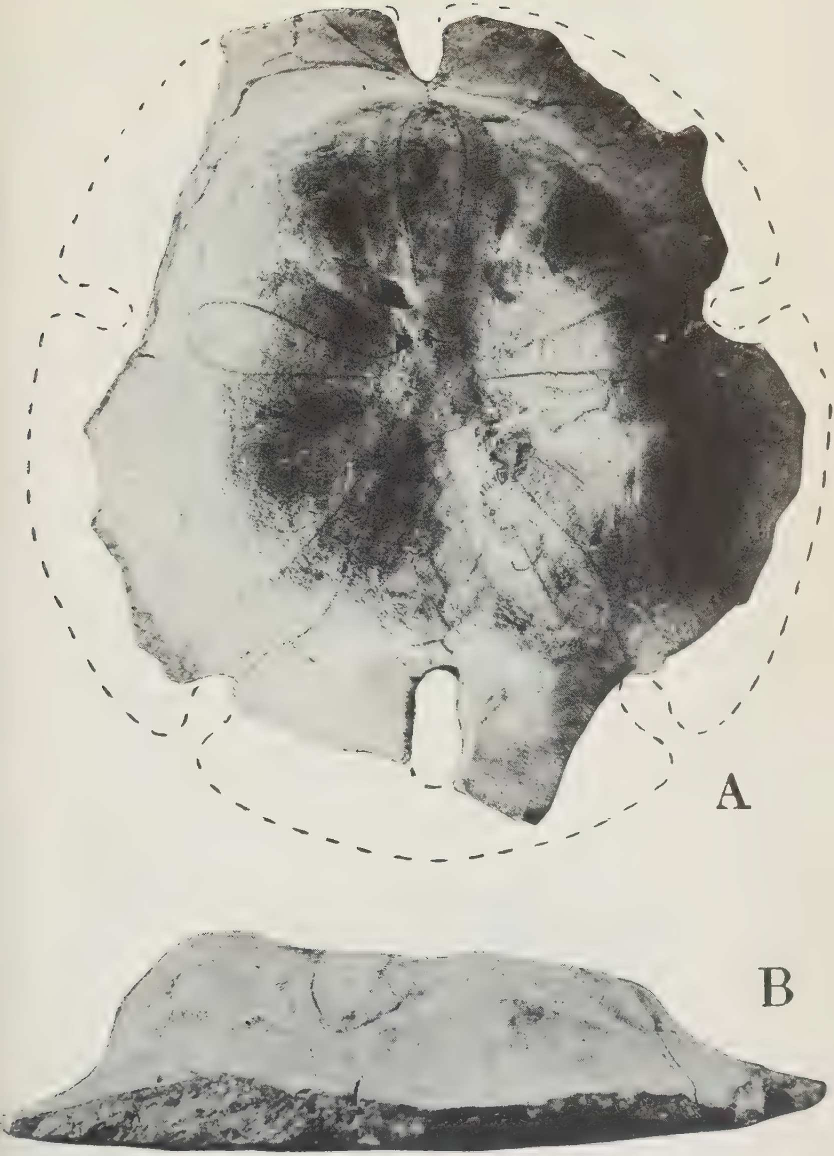
Internal Structure.—The interior of the test is almost completely filled by a calcareous cellular mass which becomes solid near the ambitus. The chambers occupied in life by some of the soft parts were traced by removal of portions of the adoral parts of the test (Text-figures 2–7). As thus laid open, the buccal cavity (*bc*) appears in plan as a five-pointed star-shaped chamber, the points of the star extending one-quarter of the distance from the peristome towards the ambital margin. Centrally, the buccal cavity extends more than half-way towards the apical disc. In specimen G (Text-figure 2), a narrow passage (*d*) connects the ray of the buccal cavity beneath ambulacrum II with the chamber (*e*, *f*, *g*) occupied by the alimentary canal. As seen from the adoral side, this channel is at first (*e*) wide and depressed; it passes round on the right of the buccal chamber to beneath the periproct (*pt*), where it contracts to a narrow passage (*f*, *g*), circular or roughly quadrate in cross-section; the arrangement and convolutions of this vary exceedingly in different specimens. In most, the narrow portion (*f*, *g*) partly overlaps the initial part (*e*): specimen E (Text-figure 5) forms an exception. The portion "*g*" is sometimes in contact with "*f*," sometimes widely separated: near the anus, "*g*" plunges beneath "*f*," and, reappearing on the other side, opens to the exterior through the periproct. In specimen K, however, "*g*" crosses beneath "*f*" at an earlier stage (Text-figure 7).

Lantern.—One pyramid has been isolated, and some are visible in the specimens (see Plate III, Fig. C). The state of preservation is unsatisfactory, but they all appear to have the usual charac-



Encope peruviana, sp. nov.

[To face p. 64



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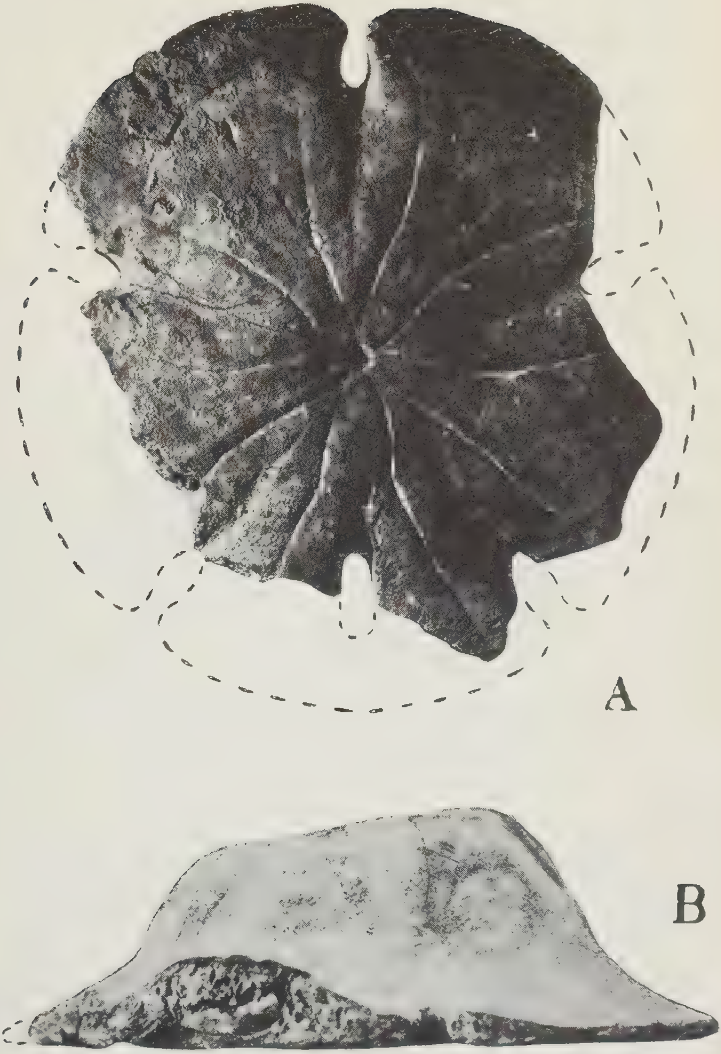
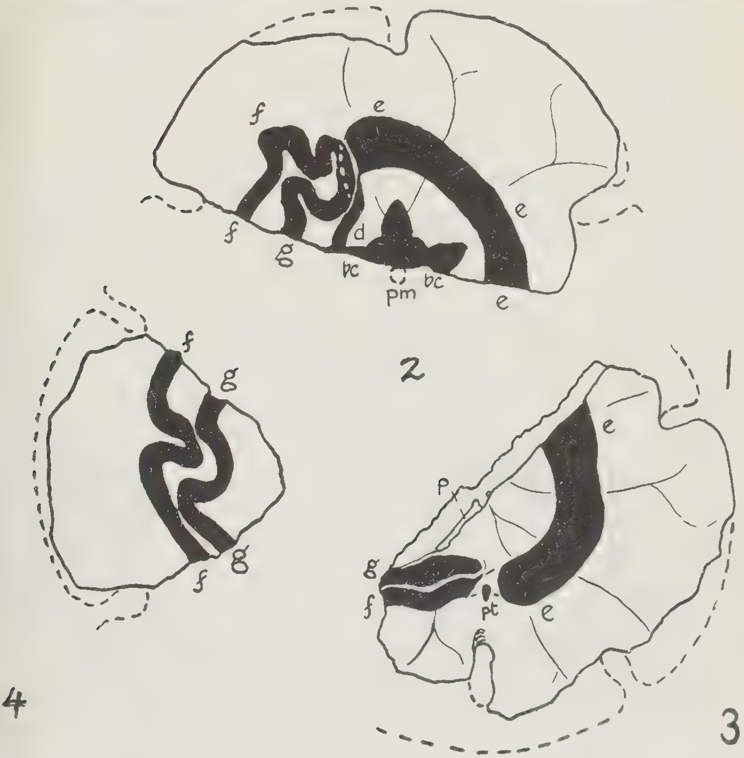


Encope peruviana, sp. nov.

teristics of *Encope*; the flanges are broad in comparison with their height.

Comparison with other Species.—*Encope* is represented from the Miocene onwards in the central part of America, on both the east and west coasts of which it is still living. *E. peruviana* is easily distinguished from all the other fossil species by the relatively great height of the corona, and the shape of the adapical surface. *E. ciae* de Cortázar (4, pp. 227–32, pls. G, H) from the (?) Miocene[1] of Cuba, approaches nearer to *E. peruviana* than any other form



FIGS. 2, 3, and 4.—*E. peruviana* sp.nov. × $\frac{3}{4}$. Portions of the adoral surface have been removed to exhibit the internal chambers. Each figure is orientated similarly. *pm* = peristome, *bc* = buccal cavity, *d*, *e*, *f*, *g* = alimentary cavity, *pt* = periproct, *p* = pyramid. The extent of the cavity *e*, *d* beneath *f*, *g* is shown by the dotted line. Fig 2, specimen G; 3, H; 4, L.

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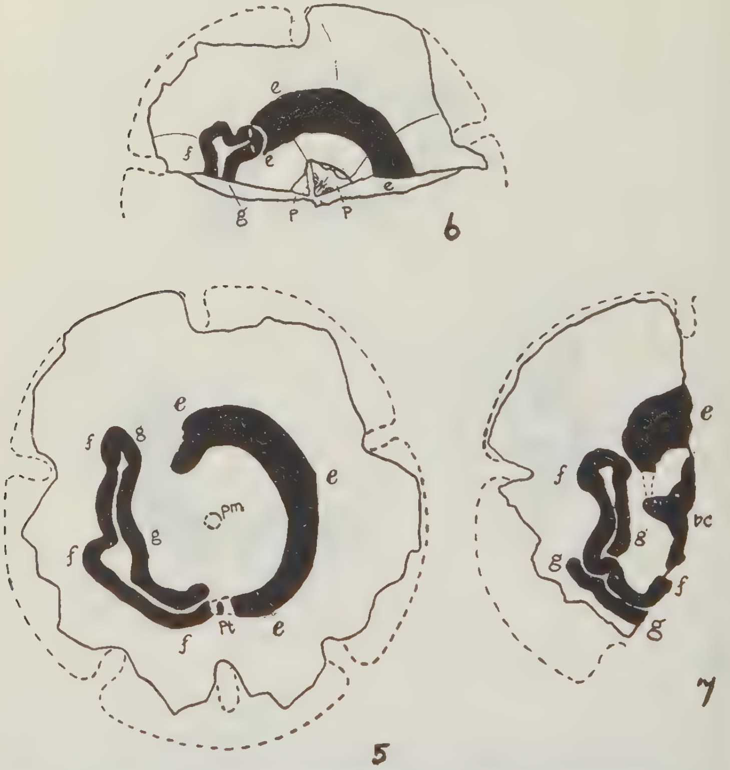
[1] Vaughan (13, p. 116) remarks of the only specimen known of this species, *Encope ciae* . . . is said by de Cortazar to come from upper Miocene deposits. The species probably belongs stratigraphically above the Anguillan horizon." = Upper Oligocene; loc. cit., p. 113).

in the shape of the adapical surface. From a flattened rim-like margin, the corona rises adapically to a central tumid portion; but the greatest height of the test is only one-seventh of the antero-posterior diameter, and is excentric posteriorly. The anterior part of the ambital outline is quite distinctive, and the petals unequal in length; the lunule is longer and narrower, and the notches shallower and more open, than in *E. peruviana*. *E. macrophora* (Ravenel)[1] from the Upper Miocene of S. Carolina and the Pliocene of Florida, approaches nearest of the fossil forms to *E. peruviana* in the ratio coronal height : antero-posterior diameter, which reaches in the larger specimens the value 1 : 5·4.



FIGS. 5, 6, and 7.—*E. peruviana* sp.nov. × $\frac{3}{5}$. Fig. 5, specimen E; 6, J; 7, K. Explanation as for Figs. 2–4.

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[1] The bibliographic history and a detailed description of this species is given by Clark and Twitchell (9, pp. 206–9, pl. xciii, figs. 2*a*–*e*; pl. xciv, figs. 1*a*–*f*, 2). They consider *Macrophora raveneli* Conrad, sometimes quoted as an *Encope*, to be based on an immature specimen of *E. macrophora*.

But the shape of the adapical surface, which rises from an inflated ambital margin " . . . towards the center and posteriorly in a low longitudinally elongate mound", is sufficiently distinctive. Further, the lunule is large and triangular, the posterior petals long and curved, and the test smaller than that of *E. peruviana*.

The other fossil forms of *Encope* are relatively flat and disc-like. *E. tenuis* Kew (7, pp. 47–8, pl. i, fig. i; pl. ii, fig. 1: and 11, pp. 136–7, pl. xxxvi, fig. 1; pl. xxxvii, figs. 1*a*, *b*) from the Pliocene of California, with the " summit [of the test] . . . immediately anterior to the lunule", has the ratio height: antero-posterior diameter on the average equal to 1 : 9 (11, p. 136). In the three species *E. annectans* (10, pp. 491–4, text-fig. 1, pl. lxv, figs. 1, 2; pl. lxvi, fig. 1), *E. platytata* (loc. cit., pp. 494–5, text-fig. 2, pl. lxvii, figs. 1, 2), and *E. megatrema* (loc. cit., pp. 496–8, text-figs. 3, 4, pl. lxviii, fig. 1) described by Jackson from the Gatun formation[1] of the Panama canal zone, the same ratio is not greater than 1 : 10. *E. gatunensis* Toula (6, pp. 489–90, pl. xxx (i), fig. 2), from the same formation, is possibly identical with *E. platytata*.[2] The ratio is less than 1 : 11 in the possibly immature *E. latus* Jackson (12, p. 51, text-fig. 7, pl. 7, fig. 7) from the Miocene (?) of Porto Rico; and reaches a minimum for the genus in *E. tatlaensis* Böse (5, pp. 71–2, pl. vi, figs. 1, 2; pl. vii, figs. 1, 2) from the Pliocene of Mexico.

The shape of the test is sufficient to distinguish *E. peruviana* from the six living species recognized by H. L. Clark (8, p. 72). Of *E. grandis* L. Agassiz, Clark writes (16, p. 172):—" This is undoubtedly the most solid sea-urchin known. An adult probably contains more carbonate of lime in proportion to the total weight than any other Echinoderm." *E. peruviana* would seem at least to share this claim. The internal structure of *E. micropora* was described by L. Agassiz (2, p. 50, pl. xix*a*, fig. 7), and of *E. michelini* L. Agassiz and *E. emarginata* Leske by A. Agassiz (3), who considered (3, p. 330) that the size of the buccal cavity, and the size and arrangement of the cavity occupied by the alimentary canal are of importance in distinguishing the two latter species. In the size of the buccal cavity, and to a less extent in the arrangement of the alimentary cavity, *E. peruviana* more closely resembles *E. emarginata* Leske.

Discussion.—Although the specimens exhibit considerable differences in the size, relative height, and inflation of the corona, and in the course of the alimentary cavity, the variations are not interdependent, and separation into more than one species has not been found possible. From the description of Clark and Twitchell (9, pp. 206–9, pl. xciii, figs. 2*a*–*e*; pl. xciv, figs. 1*a*–*f*, 2), *E. macrophora* Ravenel shows somewhat similar variation in shape and size; and H. L. Clark, in discussing the genus *Encope* (8, p. 72), writes, " . . . the large amount of material . . . shows well the variability in form of both test and lunules which characterizes some of the species," although " . . . other species . . . show very little diversity . . ." The relatively large size of the lunule and the very inflated interradial tracts of the raised central portion of the corona, shown by the largest specimen, F, may possibly be gerontic features.

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[1] Probably Lower Miocene. See footnote by T. W. Vaughan in 10, p. 489.

[2] See Jackson (12), p. 50.

LIST OF WORKS REFERRED TO IN THE TEXT.

1. L. Agassiz, *Catalogus systematicus Ectyporum Echinodermatum fossilium Musei Neocomensis*, 1840.
2. L. Agassiz, " Monographies d'Echinodermes " : *Famille des Clypéastroides*, Seconde Monographie, Des Scutelles, 1841.
3. A. Agassiz, "Revision of the Echini " : *Mem. Mus. Comp. Zool. Harvard*, vol. iii, 1872.
4. D. de Cortázar, " Descripcion de un nuevo Equinodermo de la Isla de Cuba, *Encope ciae* n.sp." : *Bol. Com. Mapa Geol. España*, tome vii, pp. 227–32, pls. G, H, 1880.
5. E. Böse, " Sobre algunas Faunas Terciarias de México " : *Inst. Geol. de México*, Bol. No. 22, 1906.
6. F. Toula, " Die jungtertiäre Fauna von Gatun am Panamakanal " : *Jahrb. k.k. geol. Reichsanst*, vol. lxi, 1911, pp. 487–530, pls. xxx–xxxi.
7. W. S. W. Kew, " Tertiary Echinoids of the Carrizo Creek Region in the Colorado Desert " : *Univ. Calif. Publ. Bull. Dept. Geol.*, vol. viii, 1914, pp. 39–60, pls. i–v.
8. H. L. Clark, " Hawaiian and other Pacific Echini " : *Mem. Mus. Comp. Zool. Harvard*, vol. xlvi, 1914, No. 1.
9. W. B. Clark and M. W. Twitchell, "The Mesozoic and Cenozoic Echinodermata of the United States " : *U.S. Geol. Surv. Mon.*, vol. liv, 1915.
10. R. T. Jackson, " Fossil Echini of the Panama Canal Zone and Costa Rica " : *Proc. U.S. Nat. Mus.*, vol. lviii, 1917, pp. 489–501, pls. 62–8. Reprinted in *Bull. U.S. Nat. Mus.*, No. 103, 1918, pp. 103–16, pls. xlvi–lii.
11. W. S. W. Kew, " Cretaceous and Cenozoic Echinoidea of the Pacific Coast of North America " : *Univ. Calif. Publ. Dept. Geol.*, vol. xii, No. 2, 1920, pp. 23–236, pls. 3–42.
12. R. T. Jackson, " Fossil Echini of the West Indies " : Contributions to the Geology and Palaeontology of the West Indies, Carnegie Institution of Washington, Publication No. 306, 1922, pp. 1–104, pls. 1–18.
13. T. W. Vaughan, " Stratigraphic Significance of the Species of West Indian Fossil Echini " : Carnegie Institution of Washington, Publication 306, 1922, pp. 105–22.
14. T. O. Bosworth, *The Geology and Palaeontology of North-West Peru*, 8vo, London, 1922.
15. E. M. Spieker, " The Palaeontology of the Zorritos Formation of the North Peruvian Oil Fields " : *John Hopkins University Studies in Geology*, No. 3, 1922.
16. H. L. Clark, *Catalogue of the Recent Sea-Urchins in the British Museum (Natural History)*, London, 1925.

EXPLANATION OF PLATES

PLATE III.

Encope peruviana sp.nov. × 1.

FIGS. A, B.—Holotype, specimen D. Fig. A, adapical view. The outline is restored by comparison with the most complete specimen, A. Fig. B, lateral view.

FIG. C.—Specimen J. A fragment broken across ambulacra II and IV, showing the compact cellular mass filling the interior, some of the chambers (*v*) beneath the ambulacra occupied by the water-vascular system, the alimentary cavity seen in three places (*e*, *f*, *g*) in section (the floor of the cavity has been removed), and two pyramids (*p*) in situ.

PLATE IV.

E. peruviana sp.nov. × 1. Specimen F.
FIG. A.—Adapical view.
FIG. B.—Lateral view.

PLATE V.

E. peruviana sp.nov. × 1. Specimen C.
FIG. A.—Adoral view.
FIG. B.—Lateral view.

On some Arthropod Remains from the Rhynie Chert (Old Red Sandstone).

By STANLEY HIRST and S. MAULIK.

(PLATES VI AND VII.)

SINCE writing the first report on the arthropods of the Rhynie Chert beds (see *Ann. Mag. Nat. Hist.* (9), xii, pp. 455–74, 5 pls., and 13 text-figs.) some additional specimens of *Palaeocharinus* have been collected. A few examples are fairly complete and well preserved, showing a considerable amount of structural detail, such as the chaetotaxy, claws of the legs, ornamentation of the chitin, eyes, etc. An account of the lateral eyes is given below. We also include notes on a supposed insect and another fossil arthropod which we refer with doubt to the aquatic *Merostoma.* All the illustrations in this little paper have been drawn by Miss Violet Borrow, A.R.C.A., with the aid of a camera lucida under our personal supervision.

Order ANTHRACOMARTI.

Genus *Palaeocharinus* Hirst. (Plate VI.)

In some specimens of this fossil Arachnid a number of small pale circular appearances can be seen on the large lateral tubercle (ocular tubercle ?). These little circular structures, which probably are ocelli, are few in number and form an irregular series (almost double in places) running across the tubercle (Plate VI). In the footnote on page 462 of the first report on Arachnids from the Rhynie Chert, it is suggested that the large lateral tubercular or mound-like structures on the carapace are presumably compound eyes. The presence of only a few ocelli on these comparatively large structures seems to indicate, however, that they are more likely to be ocular tubercles than compound eyes. The median pair of eyes are very distinct in some of our examples of *Palaeocharinus.* The tarsi of the legs of some specimens of *Palaeocharinus* are furnished with three distinct claws, the unpaired ventral claw being quite short, however. Palp apparently with a single rather thick claw.

Order MEROSTOMA ?

Crania rhyniensis gen. and sp. nov. (Plate VII, Text-fig. 1.)

This animal is only represented by very fragmentary remains, hence it is not possible to describe the general shape of the body. Judging by the structure of the legs, it belongs to the aquatic *Eurypterids*. The following is a detailed account of this fossil so far as the material permits. Several sections of Rhynie Chert prepared by Mr. Hemingway and also a few fragments collected by Mr. Cran show a number of elongated structures (Fig. 1 B), possibly sections of tergites and sternites. Some of these elongated strips of chitin have short narrow bars or septa separating the two surfaces. It is possible that these septa are the supports of lateral keels; they may, however, be sections of chitinous bars serving to ornament or strengthen the integument. Some of the

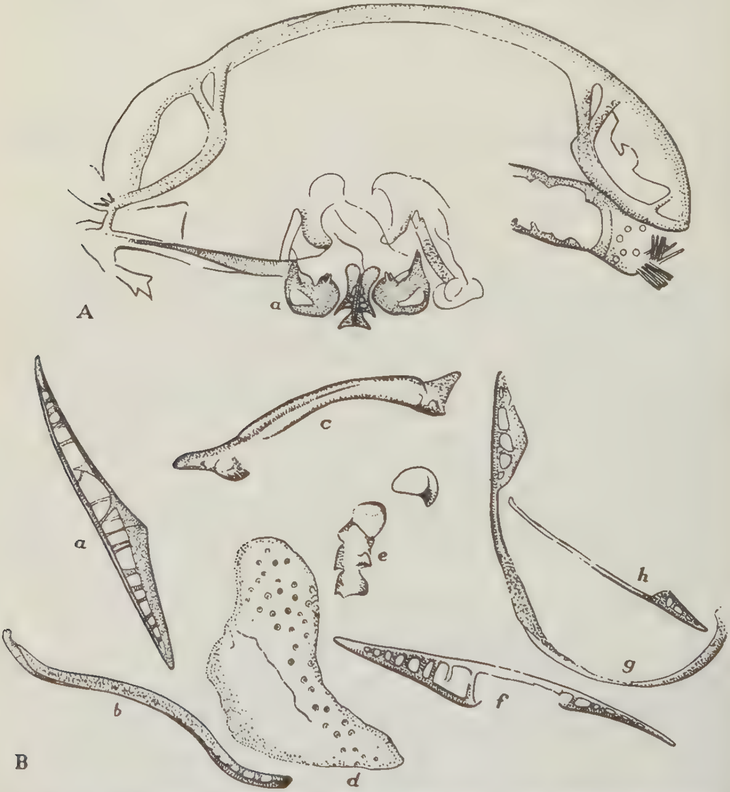
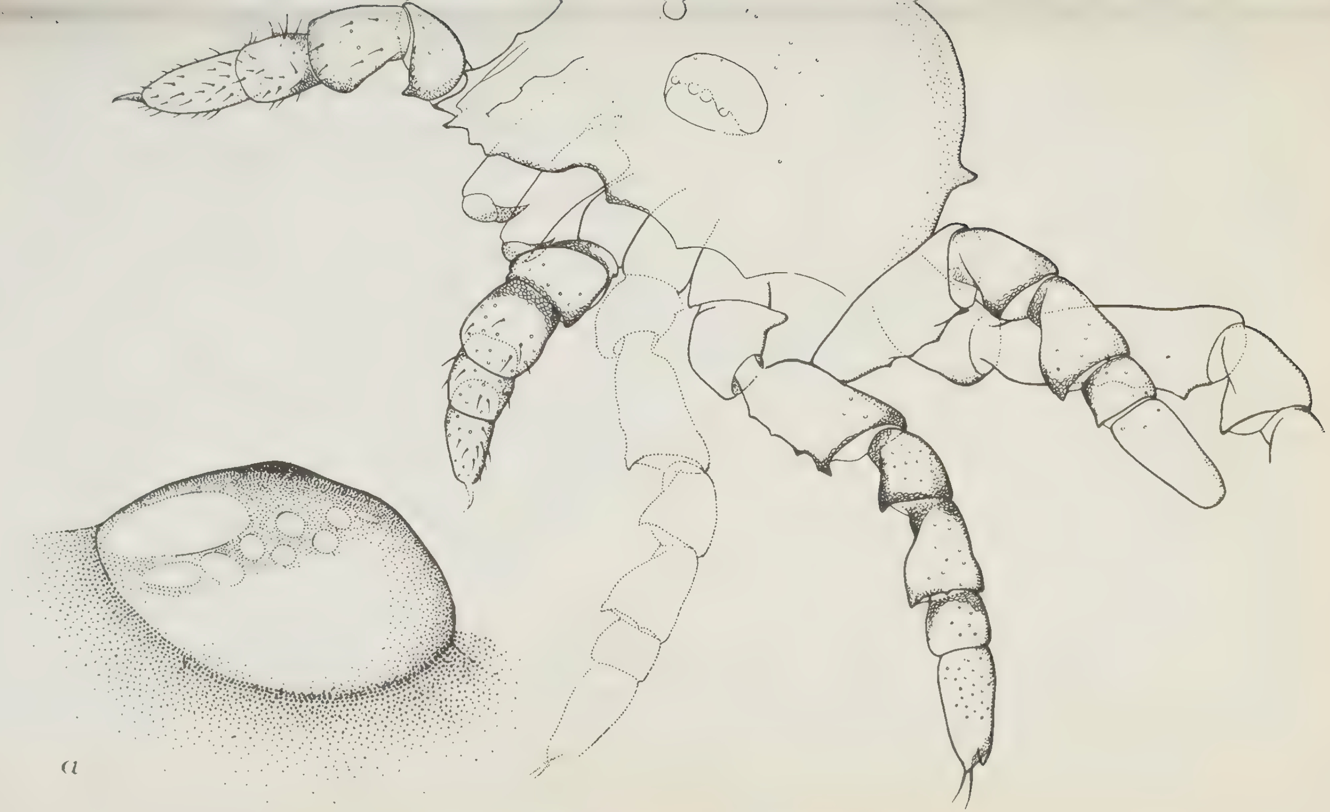
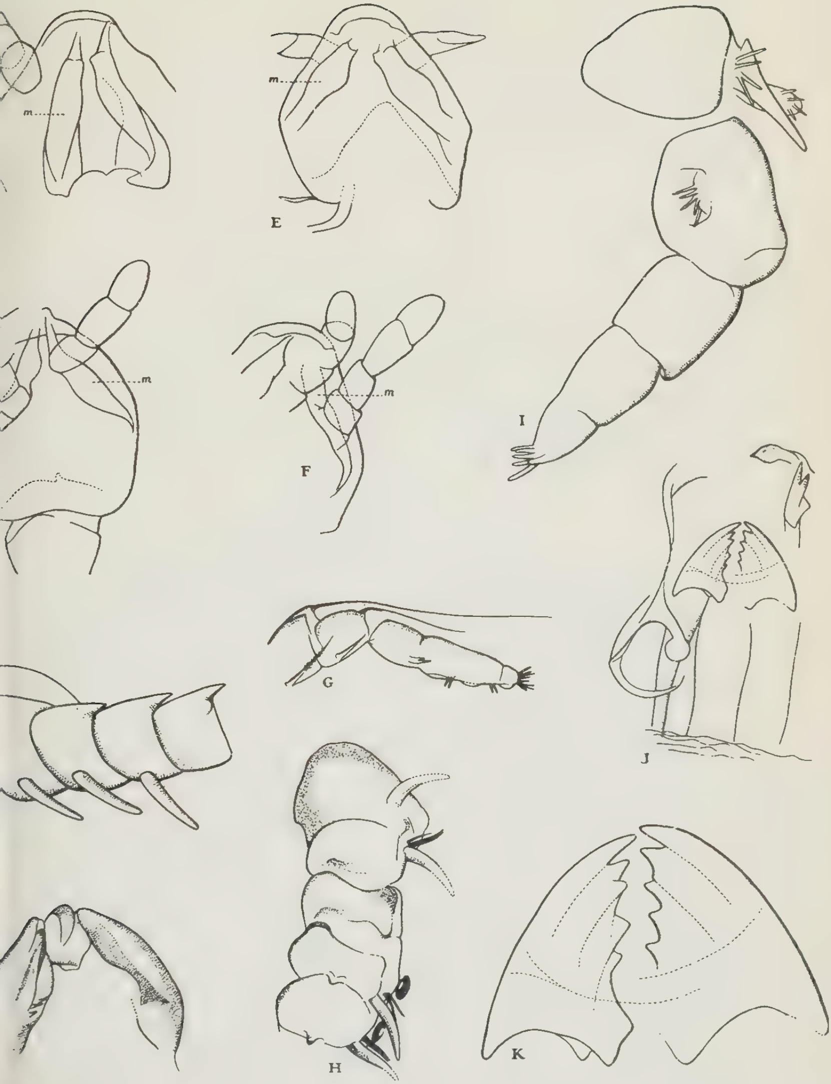


FIG. 1.—*A*, Transverse section of *Crania rhyniensis*. *B*, Scattered fragments of *Crania rhyniensis* sketched as they lie in the matrix. *a*, *b*, *c*, *f*, *g*, *h*, Portions of the body. *d*, Part of the integument. *e*, Part of a limb.



PALAEOCHARINUS SP. CARAPACE WITH LATERAL AND MEDIUM EYES, ALSO PALP AND LEGS.
a. Lateral ocular tubercle with ocelli, greatly enlarged.

[*To face p. 70.*



3, E, F. *Rhyniella praecursor*, gen. and sp. nov. Views of head.
, H, I. *Crania rhyniensis*, gen. and sp. nov. Views of appendages and parts of appendages. D. Supposed chelicerae of same.
K. Mandibles of supposed larval insect.

larger fragments are strongly arched and perhaps represent a transverse section of the body. Several pieces of what is evidently the surface integument are ornamented with dark little specks possibly granules and also sometimes with little circles formerly the base of hairs. The paired structure shown in Pl. VII, Fig. D, is perhaps the mandibles of the animal. It is difficult to explain the latticework arrangement marked *a* in Fig. 1A, possibly it is an endosternite or else the base of some appendage. Segments of legs are usually shorter than wide and often have the anterior (?) surface produced to form a sharp dentiform angle. Each segment of a leg is usually furnished posteriorly with a fairly long flattened setiform process rather like those present in *Eurypterus*, etc. On some segments there is also a little sucker-like disc with a striated margin. A group of setae is placed beside each of the long setiform processes. Tarsi pointed, apparently without claws and with tufts of terminal hairs or setae. Length of segment of legs ·087 mm., its width ·17 mm., length of spine-like process on leg ·11 mm. The supposed *Eurypterid* (Merostoma) described above presumably is a form that lived in fresh water. It seems to occur fairly frequently in the Rhynie Chert beds but always in very fragmentary condition.

Class INSECTA.

Rhyniella praecursor gen. and sp.n.

Only heads of this presumed insect have so far been discovered. In all there are four examples each preserved in separate little splinters of Rhynie Chert. The head is rather triangular, being narrowed anteriorly, its anterior margin being divided off by a distinct curved line. In one specimen the palp is seen to be four jointed and it is probable that this is the correct number of segments, but only three are visible in some cases. The basal segment is the shortest, the two distal segments are fairly elongated, the penultimate segment being slightly longer than the distal one. Mandibles (m in Pl. VII, Figs. A, B, E, F) distinct and evidently they were strongly chitinized. Just before the distal end the mandible has a protuberance on its inner side, the end itself being drawn out and slender.

Measurements.—Length of head: specimen No. 2, ·32 mm. its width, ·21 mm. Length of head: specimen No. 3, ·31 mm. its width, ·21 mm. Length of head: specimen No. 4, ·30 mm. Length of first segment of antenna ·05 mm., of second segment of antenna ·06 mm., of third segment ·08 mm., of fourth ·07 mm.

Locality.—Rhynie, Aberdeenshire (Cran Coll.).

LARVAL INSECT ?

The figures labelled J and K on Plate VII represent some jaw-like structures found in a splinter of Rhynie Chert. Possibly they are the mandibles of the larva of an insect. They are rather thin and delicate, apparently not having been very strongly chitinized.

Note on a Riebeckite-Bearing Rock from the Shetlands.

By F. Coles Phillips, B.A., Sedgwick Museum, Preston Read Research Student in the University of Cambridge.

(PLATE VIII.)

I. Introduction.
II. Field Occurrence.
III. Petrographic Description.
IV. Discussion and Comparison.

I. Introduction.

THE purpose of this note is to place on record the occurrence of the soda-bearing amphibole, riebeckite, in a particular type of dyke-rock in the Shetland Islands. To explain its field-relations a brief sketch of the general geology of the group is necessary.

The islands consist mainly of an old series of schists and paragneisses, with a strike over the greater part of the area about N. 10° E., and generally a steep dip towards the west. Included in this series is a group of older intrusions, developed chiefly in the north-east. Around the eastern and western margins of Mainland occur patches of sediments—conglomerates, grits, and sandstones—of which the age is determined by palaeontological evidence as Old Red Sandstone. Along the eastern margin, where the sediments are comparatively unaltered, the patches rest sometimes with a normal unconformity and sometimes with a faulted junction on the underlying metamorphics. In the western area, around Walls and Aithsting, there is a shallow syncline of more altered sediments, indurated sandstones, and cleaved shales. Further north still is developed an extensive area of igneous products, the age of which is determined as Old Red Sandstone by occasional interbedded sediments.

II. Field Occurrence.

The igneous activity in this area may be summarized as follows :—

1. Volcanic phase : Tuffs ; lavas of Eshaness.
2. Main intrusive phase : Earlier basic intrusives—gabbro ; main acid intrusives—granites and modifications.
3. Phase of minor intrusions : Satellite dykes ; granophyres ; later basic dykes.

The granophyres bearing riebeckite, with which this note is concerned, occur as dykes cutting the acid portion of the main intrusives. They have so far been observed mainly around the south-eastern and eastern flanks of Ronas Hill. The acid phase in this most northerly mass differs from more normal granites occurring to the south in the extreme scarcity of any dark minerals. The general appearance of the reddish hand-specimens recalls that of a typical nordmarkite. In thin slices the rock is seen to consist of a coarse-textured intergrowth of quartz with a somewhat kaolinized felspar. Obvious microcline may occur, and small amounts of acid plagioclase are sometimes present, but the bulk of the felspar is a fine perthite. Primary magnetite is present and much secondary dusty limonite. From the analysis stated below it will be seen that the rock is rich in alkalies.

Many of the dyke-rocks of this area are merely apophyses of the granite, and resemble it closely except for a finer grain and slightly greater acidity. The structure is sometimes a graphic intergrowth, sometimes approaching the mortar-structure of a typical aplite.

III. PETROGRAPHIC DESCRIPTION.

The riebeckite-bearing dykes cut the alkaline " granite " described above. In the hand-specimens they are blue-grey to brown, with scattered pink phenocrysts of felspar up to 3 mm. in length, smaller phenocrysts of quartz and occasional black phenocrysts. Beneath the microscope there is seen to be a distinct tendency to glomero-porphyritic structure.

Quartz is present in the phenocryst stage of crystallization in clear euhedral crystals. Most of the crystals show extensive corrosion with re-entrant bays, and often strain shadows between crossed nicols.

Orthoclase is the chief porphyritic mineral, in good euhedral crystals with a prominent cleavage parallel to 001 and another less prominent. In ordinary light they are somewhat turbid, more so around the margin than towards the interior. Between crossed nicols they usually show good carlsbad twins, and occasionally a twin apparently referable to the baveno law. Polarized light reveals also the alteration of much of the interior of the crystals.

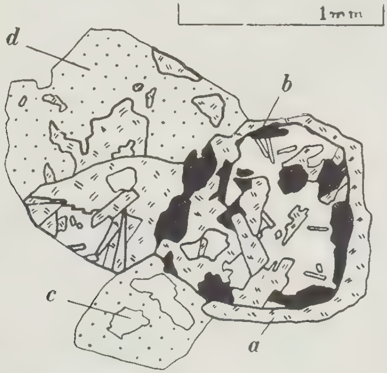


FIG. 1.—Altered phenocryst in granophyre, Grut Wells, Ronas, Mainland. *a*, Epidote, sometimes in good euhedral crystals. *b*, Riebeckite. *c*, Albite. *d*, Cloudy felspar.

In some parts remains of a normal perthitic intergrowth can be seen, but there is an extensive development of quartz and clear albite in small elongated crystals, sometimes with a rough parallel orientation. The appearance of one of these phenocrysts in polarized light can be appreciated from the photograph (Pl. VIII, Fig. 2).

The ferromagnesian phenocrysts are now represented by pseudomorphs (see Text-figures 1 and 2). In some instances these preserve clearly the angles of the prism zone of an original amphibole. The exterior margin of the pseudomorph is marked by a ring of granular, pale-green, almost non-pleochroic epidote. Within this, occur euhedral crystals of epidote, associated with patchy or fibrous aggregates of strongly pleochroic riebeckite, the whole being set in a matrix of clear albite, often optically continuous over a large portion of the pseudomorph. The outer border of granular epidote is sometimes surrounded by a zone in which much fine dusty iron-ore is disseminated through the ground-mass.

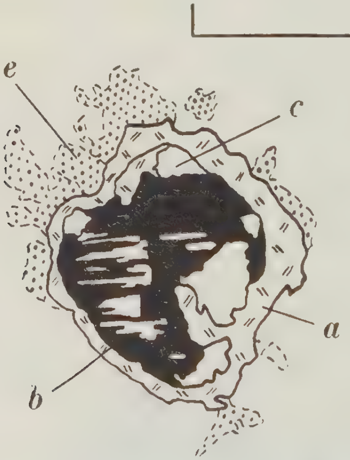


Fig. 2.—Another phenocryst. *a*, Epidote, mainly granular. *b*, Riebeckite, fibrous and obviously secondary. Clear streaks within the opaque area represent fibres not in the position of maximum absorbtion. *c*, Albite. *e*, Outer zone of dusty iron oxides.

The ground-mass is composed of quartz and felspar with riebeckite. The first two minerals are grown together in a graphic to granophyric manner on a very fine scale, and to a varying degree of perfection. The fine-grained character renders accurate determination of the felspar difficult, but its refractive index is considerably lower than 1·54, and it is presumably almost entirely albite.

Riebeckite occurs in small acicular crystals of one habit only. Nothing has been observed resembling, for example, the well-known spongy habit of the mineral in the rocks of Socotra (6)[1] and Ailsa Craig (7). The typical pleochroism is displayed :—

X, Y : intense indigo-blue.
Z : greenish-brown.

The extinction angle X ∧ C, difficult to measure with any precision, is only a few degrees.

Very little iron-ore can be seen, the riebeckite apparently taking the place of other ferromagnesian minerals as suggested by Harker in the case of the Mynydd Mawr rock (1, p. 52). Occasional minute, almost colourless needles in the ground-mass may possibly be referable to the same species as those of the Mynydd Mawr rock.

IV. Discussion and Comparison.

Below is given an analysis of the riebeckite-bearing rock, together with one of the " granite " which it cuts, and others of rocks from different localities for comparison :—

	I.	II.	III.	IV.
SiO_2	74·79	74·57	73·82	73·93
Al_2O_3	10·93	13·39	10·59	12·29
Fe_2O_3	2·26	1·46	2·18	2·91
FeO	1·64	·32	2·98	1·55
MgO	·04	·08	·04	·04
CaO	·53	·24	·28	·31
Na_2O	4·25	4·72	4·20	4·66
K_2O	4·79	4·72	4·57	4·63
H_2O+	·19	·35	·49	·41
H_2O-	·27	·14	·39	—
TiO_2	·36	·20	·13	·18
MnO	n.d.	n.d.	P_2O_5 ·08	—
	100·05	99·99	99·75	100·91

I. Riebeckite-granophyre, Grut Wells, Ronas, Shetland. (Anal. F. Coles Phillips.)
II. Alkaline granite, S. flank of Ronas Hill, Shetland. (Anal. F. Coles Phillips.)
III. Riebeckite-granite, Rosemount, Colorado. (Anal. G. Steiger.) *U.S.G.S.B.*, 419, 1910, p. 100.
IV. Granite, Hardwicke Quarry, Quincy, Massachusetts. (Anal. H. S. Washington.) *A.J.S.*, vi, 1898, p. 181.

The calculated Norm shows :—

Quartz	31·74
Orthoclase	28·36
Albite	29·34
Acmite	5·54
Diopside	3·38
Magnetite	·46
Ilmenite	·61
Water	·46
	99·89

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[1] Figures in parentheses refer to references at end of article.

An approximate Mode has been calculated :—

Quartz	32·0
Orthoclase	28·5
Albite	28·0
Riebeckite	8·5
Epidote	1·0
Iron-ores	·6
Water	·3
	98·9

The close agreement of the analyses of the riebeckite-bearing dyke-rocks and of the " granite " suggests relationship to the same magma. Moreover, the granophyric structure in the ground-mass is closely similar to that of the dyke-rocks without riebeckite described above as evident apophyses of the " granite ". This is held to justify the assumption that the riebeckite-bearing rocks belong to the same cycle of igneous activity as the " granite ", and are accordingly O.R.S. in age. Since they occur within the granite, which is itself a late acid phase of the cycle, they appear to represent the last stage of consolidation. It has not been possible to observe their direct relationship to the other dyke-rocks, which are here considered earlier owing to their obviously closer field-relationship to the " granite ".[1]

The characters of the ferromagnesian phenocrysts described above indicate that they are pseudomorphs after amphibole. The abundance of epidote in them indicates that this original amphibole was calcic. The pseudomorphs now consist of epidote, riebeckite, albite and iron-ores. This chemical change involves hydration and the addition of soda.

Calcic amphibole + alkaline solutions = epidote + riebeckite + albite + iron-ores.

The ground-mass of riebeckite and albite with quartz, representing the final products of consolidation, indicates the increasing alkalinity of the magma, and supports the hypothesis that the source of the alkali and water was late-magmatic hydrothermal solutions.

In this connexion, the rocks described by Laitakari (4) under the name Helsinkites are of interest. They consist almost entirely of albite and epidote. The albite occurs in fresh, clear crystals, between which lie radial aggregates of epidote, only sometimes idiomorphic towards the felspar (idem, Abb. 2). Laitakari considers these minerals direct crystallizations from a magma, the high water-content and low temperature of which, at the time of consolidation, have determined the appearance of the CaO in epidote rather than in a calcic plagioclase. It is precisely these conditions of hydration and temperature which would prevail in the late stages of crystallization of the magma which has given rise to the dyke-rocks described.

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[1] The " later basic dykes " of the above table also cut the granites, but have not been found in the same areas as the riebeckite-bearing rocks.

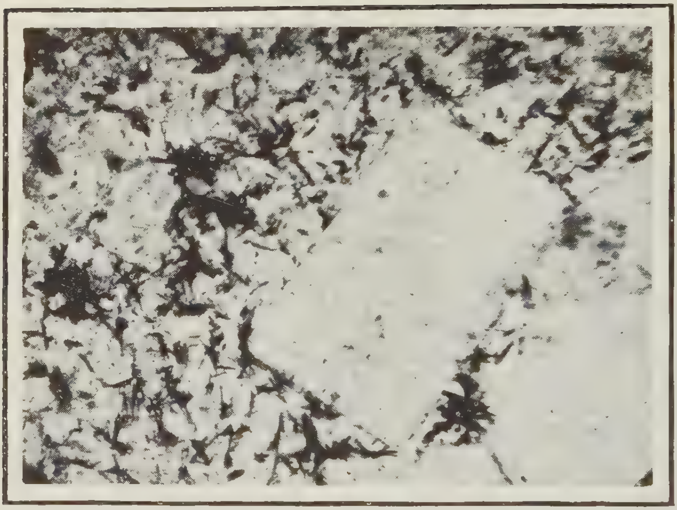

FIG. 1.—RIEBECKITE-GRANOPHYRE, GRUT WELLS, RONAS, SHETLAND. × 40.

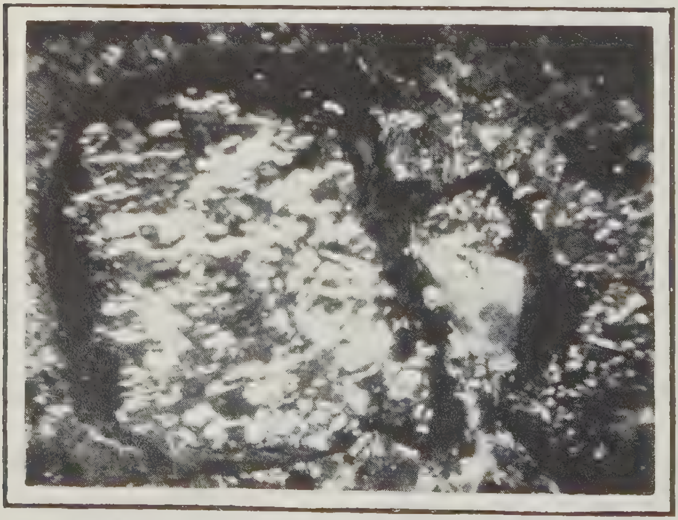

FIG. 2.—ALTERED ORTHOCLASE PHENOCRYST, RIEBECKITE-GRANOPHYRE, GRUT WELLS, RONAS. × 40.

To face p. 77.]

The presence of lamprophyre dykes in the Shetlands has been described by Flett (5). Very little work has been done on these rocks, but the possibility is here mentioned of these also being part of the O.R.S. activity. Of the similar dykes in the Orkneys, Flett states that they have generally been assumed to be Tertiary, but that they have only been proved to be later than the John-o'-Groats Sandstone. The possible association of these lamprophyres with the aplites and granophyres is suggestive. If work on the alkaline members of the O.R.S. igneous products of Shetland confirms this age for the Orkney dykes important support may be provided for the hypothesis of Broegger that they may be linked up with the alkaline Devonian province of Christiana.

ACKNOWLEDGMENTS.

A portion of the expenses of field-work in the Shetlands was defrayed by a grant from the Daniel Pidgeon Fund of the Geological Society of London. I wish to record my indebtedness to Mr. Harker, Mr. A. Hutchinson, and Dr. C. E. Tilley for help and advice and to numerous residents in Shetland.

REFERENCES

1. A. Harker, *Bala Volcanic Series*, 1889.
2. —— " Tertiary Igneous Rocks of Skye " : *Mem. Geol. Surv. U.K.*, 1904.
3. B. N. Peach and J. Horne, " Old Red Volcanic Rocks of Shetland " : *Trans. Roy. Soc. Edin.*, xxxii, 1884, p. 359.
4. A. Laitakari, " Einige Albitepidotgesteine von Sudfinnland " : *Bull. Com. Geol. Fin.*, 1918, No. 51.
5. J. S. Flett, " Trap Dykes of the Orkneys " : *Trans. Roy. Soc. Edin.*, xxxix, 1900, p. 865.
6. A. Sauer, *Zeit. d. deutsch. geol. Gesellsch.*, xxxviii, 1886, pp. 641, 653.
7. J. J. H. Teall, *Min. Mag.*, ix, 1891, pp. 219–21.

EXPLANATION OF PLATE VIII.

Fig. 1.—Riebeckite-granophyre, Grut Wells, Ronas, Shetland. Ordinary light; × 40. Porphyritic orthoclase, showing cleavage and turbid alteration. Ground-mass of acicular riebeckite with albite and quartz.

Fig. 2.—Altered orthoclase phenocryst, riebeckite-granophyre, Grut Wells, Ronas. Crossed nicols; × 40. Showing unaltered margin (in extinction) and aggregate of secondary felspar and quartz in the interior.

On New Ammonites from the English Chalk.

By L. F. Spath, D.Sc., F.G.S.

AMMONITES are comparatively common in the Cenomanian or Lower Chalk, become rarer in the Turonian or Middle Chalk, and are very scarce in the Upper Chalk. On a former occasion,[1] when pointing out that while ammonites were unknown from the *Micraster cor-testudinarium* Chalk of England, they occurred in the same Chalk in the north of France, the writer was inclined to attribute this absence or scarcity to limited horizontal distribution of the ammonites. The possibility, however, of there being gaps in the Chalk succession, for example at the horizon of *Actinocamax plena*, at the Chalk-Rock, in and above the *cor-anguinum* zone, etc., cannot be denied. The zone of *Micraster cor-anguinum* is not quite so barren as the zone below, but the only ammonites hitherto known from it are doubtful examples, probably referable to *Parapuzosia*. One impression, on an oyster, of part of the ventral area of a large specimen, possibly of *P. corbarica* Grossouvre sp.,[1] was collected by Mr. Dibley in the London-Portland Pit at Northfleet, Kent, and Dr. Rowe[2] recorded probably comparable *Parapuzosia* ("ammonites of the *leptophyllus* group") from Dorset and Yorkshire.[3]

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[1] Spath, in Lang, Spath, and Richardson, "Shales-with-Beef": *Quart. Journ. Geol. Soc.*, vol. lxxix, 1923, p. 87.

The recent discovery, therefore, by Mr. Dibley, of two new ammonites from Cliffe, Kent, seems important enough to be recorded at once. The specimens were in a collection presented to the Rochester Museum by Miss Gladys Francis, and Mr. Dibley, recognizing the great value of the ammonites, was immediately willing to transfer them to the British Museum (Natural History), with the consent of the original donor. The two ammonites are undoubtedly true *Mortoniceras*, not previously known from this country, and are very close to the genotype species, namely *M. texanum*, Roemer sp.,[4] a zonal fossil of the Lower Santonian. This species has a wide horizontal distribution, being known from both the Old and the New Worlds. Since the various allied forms included in this comprehensive species by previous authors have only lately been the subject of a paper by Yabe and Shimizu,[5] there is no need to discuss them in detail and the preservation of the English specimens is not good enough for a definite reference to one variety rather than another.

The accompanying table demonstrates the scarcity of ammonite records from the Upper Chalk. Corrections of this list—not free from speculative taint—will no doubt become necessary, and it is hoped that there will be additions to the list of English species. Records like that of *Ammonites wharramiensis* (Mortimer MS.) Lamplugh,[6] could not be utilized for the present list, and there appears to be no doubt that the citations, in geological literature, of species like "*Amm. peramplus*" for the Middle

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[1] "Ammonites de la Craie Supérieure": *Mém. Carte Géol. Dét. France*, 1893, p. 174, pl. xxvii, fig. 1.

[2] "Zones of the White Chalk": *Proc. Geol. Assoc.*, vol. xvii, 1901, p. 75. Ibid., vol. xviii, 1904, p. 252.

[3] The record of *Ammonites* (?) *pseudogardeni* Schlüter, from the *cor-anguinum* zone (instead of the *quadratus* zone) of Yorkshire, is obviously due to a slip.

[4] *Kreidebildungen von Texas*, 1852, p. 31, pl. iii, fig. 1 *a–c*.

[5] "Note on the Genus *Mortoniceras*," *Japanese Journ. Geol. and Geog.*, vol. ii, No. 2, 1923, pp. 27–30.

[6] In Rowe, loc. cit., pt. iv, Yorkshire, 1904, p. 288.

Chalk, or of "*Amm. leptophyllus*" for the Upper Chalk, cover a variety of forms. The table may also serve, provisionally, to carry to the top of the Cretaceous the detailed lists of ammonite zones of the Cenomanian, Albian, Aptian, and Neocomian, published on previous occasions.[1]

Sharpe's "Description of the Fossil Remains of Mollusca found in the Chalk of England—Cephalopoda" was issued by the Palaeontographical Society in three parts between 1853 and 1858, and was, unfortunately, left uncompleted. It has for many years been in need of revision, and the lack of names for a multitude of new forms is embarrassing to those who are either working on, or are constantly asked to identify, Chalk ammonites. The use of the Jurassic genus *Haploceras* for a group of Chalk ammonites in a recent work shows that even the older generic names are not widely known. A complete revision of Sharpe's monograph, unfortunately, cannot be attempted at this stage; meanwhile, however, the new names necessary for the present table may be briefly defined as follows:—

(1) **Submortoniceras** gen. nov. Genotype *Mortoniceras woodsi* Spath ("Cretaceous Cephalopoda from Zululand": *Annals South African Museum*, vol. xii, pt. vii, No. 16, 1921, p. 232, pl. xxi, figs. 1*a*–*d*). The Campanian forms differ from the earlier true *Mortoniceras* (genotype *M. texanum* Roemer sp., referred to above) chiefly in the more continuous keel and progressive decline of ornamentation as well as of other characters. The still earlier so-called *Mortoniceras* of the Upper Albian (*Pervinquieria* J. Böhm, 1910 = *Inflaticeras* Stieler, 1920) are somewhat homœomorphous, but unrelated (family Pervinquieridæ n.n. to replace Inflaticeratidæ Spath).

(2) **Pseudoplacenticeras** gen. nov. Genotype *Amm. milleri* Hauer ("Neue Cephalop. a.d. Gosaugebild. d. Alpen": *Sitz. Ber. K. Acad. Wiss. Wien*, vol. liii, 1 (1866), p. 304, pl. ii, figs. 1–2). This differs from *Diplacmoceras*, Hyatt, by absence of ventral groove, inner row of tubercles, and less compressed young stage. **Proplacenticeras** gen. nov., proposed for *P. fritschi* Grossouvre sp. (loc. cit., 1893, p. 124, pl. v, fig. 1) is of Turonian-Coniacian age and differs in suture-line as well as in whorl-shape and ornamentation. *Proplacenticeras* is not equivalent to Vredenburg's ("Ammonites of the Bagh Beds": *Records Geol. Surv. India*, vol. xxxvi, 1907, p. 116) "Group of *Placenticeras fritschi*" which comprises other elements, including *Knemiceras* Boehm, *Parengonoceras* Spath, and **Metaplacenticeras** gen. nov., proposed for *Placenticeras pacificum* J. P. Smith ("Development and

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[1] Spath, "Ammonite Horizons of the Gault and Contiguous Deposits". Summ. of Progress for 1922 (1923), *Mem. Geol. Survey*, pp. 139–49. Spath, "Monograph of the Ammonoidea of the Gault": pt. 1, *Pal. Soc.* vol. for 1921 (1923), p. 4. Spath, "Ammonites of the Speeton Clay and Subdivisions of the Neocomian": GEOL. MAG., Vol. LXI, 1924, pp. 73–89.

Phylogeny of *Placenticeras* " : *Proceed. Calif. Acad. Sci.* (3), Geol. (1900), p. 181, pl. xxvi.) This last is characterized by its falcoid ribbing and has a suture-line distinct from that of the typical *Placenticeras placenta* (De Kay).

(3) **Prionocycloceras** gen. nov. Genotype *Prionocyclus guyabanus* (Steinmann) Gerhardt (" Beitr. zur Kenntn. der Kreideformat. in Venezuela und Peru." Neu. Jahrb. f. Min. etc., Beil. Bd. xi (1897), p. 197, pl. v, figs. 22 *a–c*). Transitional between *Prionocyclus* and *Gauthiericeras*, with the keel tending to become continuous, as in the latter.

(4) **Neancycloceras** gen. nov. Genotype *Ancyloceras bipunctatum* Schlüter (" Cephalopod. Ob. Deutsch. Kreide." Palaeontogr., vol. xxi, pt. iv (1872), p. 98, pl. xxix, figs. 1–3). This stock of the *mucronata* zone is obviously distinct from *Oxybeloceras* Hyatt, with which the writer (loc. cit., Zululand, 1921, p. 254) had formerly united it. The Coniacian **Phlycticrioceras** gen. nov. (genotype *Ancyloceras douvillei* Grossouvre, loc. cit., 1893, p. 254, pl. xxxv, fig. 8), with a median crest, is sufficiently distinct to be placed in a separate family : Phlycticrioceratidae nov.

(5) *Glyptoxoceras* Spath (" Senonian Ammonoidea from Jamaica " : Geol. Mag., Vol. LXII, 1925, p. 30), includes " *Helicoceras* " *hibernicum* Tate (" Correlation of the Cretaceous Formations of the North-East of Ireland," *Quart. Journ. Geol. Soc.*, vol. xxi, 1864, p. 37, pl. iii, fig. 2) doubtfully referred on a former occasion (loc. cit., Zululand, 1921, pp. 254–7) to *Exciteloceras* Hyatt, also the Indian " *Anisoceras* " discussed in the same paper.

(6) The genus *Baculites* is now restricted to the typical group of *Baculites vertebralis* Lamarck (= *B. faujasi* Lamarck, in Binkhorst, *Mon. d. Gast. et Ceph. d. l. Craie supér. d. Limbourg*, 1861, p. 40, pl. v*d*, fig. 1*a*, genolectotype) with elliptical cross-section ; and the new genus **Euhomaloceras** gen. nov. is proposed for Meek's group *b* (" Invertebr. Cret. and Tert. Fossils " : *U.S. Geol. Survey Territ.*, vol. ix, 1876, p. 392) with *B. incurvatus* Dujardin (in d'Orbigny, *Pal. Franç., Terr. Crét.*, vol. i, 1842, p. 564, pl. cxxxix, fig. 8) as genotype and **Eubaculites** gen. nov. for the carinate forms of the group of *E. vagina* (Forbes) and *E. otacodensis* Stoliczka sp. (Kossmat, " Untersuch. Südind. Kreideform " : *Beitr. Pal. Geol. Österr.-Ung.*, vol. ix, 1895, p. 157, pl. xix, figs. 15*a*, *b* genotype).

(7) **Pseudopuzosia** gen. nov. Genotype *Desmoceras marlowense* Noble (" New Species of *Desmoceras* from Chalk Rock, etc." : Geol. Mag., 1911, p. 398, Figs. 1, 2). This was compared to *Desmoceras pyrenaicum* Grossouvre—which is a *Schluteria*—but it has more resemblance to the true *Desmoceras* (" *Latidorsella* ") of the Albian, and is quite distinct from the contemporaneous *Austiniceras*.

(8) **Allocrioceras** gen. nov. Genotype *Crioceras ellipticum* (non

TABLE.—SUBDIVISIONS OF THE WHITE CHALK.[1]

Stage.		*Age.*	*Ammonite horizons.*	*Approximate zonal equivalent.*	*British genera and localities.*
DANIAN		*Hercoglossan*	*[Hercoglossa danica]*		
			. . .		
MAESTRICHTIAN		*Sphenodiscan*	*Indoceras baluchistanense*		
			Sphenodiscus siva		
		Parapachydiscan	*Parapachydiscus neubergicus*	Zone of *B. mucronata*	*Phylloceras, Gaudryceras, Parapuzosia, Parapachydiscus, Menuites, Bostrychoceras, Diplomoceras, Neancyloceras* (4), *Glyptoxoceras* (5), *Baculites* (6) (Norwich, Antrim).
			Menuites menu		
			Bostrychoceras polyplocum		
SENONIAN	CAMPANIAN		*Pseudoschloenbachia umbulazi*	(up. & middle ?)	
			Kossmaticeras theobaldianum	do.	
			Hoplitoplacenticeras vari	(lower ?)	
			Eupachydiscus levyi		
		Hoploscaphitan	*Submortoniceras*(1) *delawarense*	Zone of *A. quadrata*	*Hoploscaphites binodosus, H. inflatus*, etc. *Hauericeras* cf. *pseudogardeni* Yorkshire.
			Hoploscaphites binodosus		
			Hauericeras pseudogardeni		
		Stantonoceratan	*Diplacmoceras bidorsatum*	*Off. pillula*	
			Pseudoplacenticeras (2) *milleri*		
	SANTONIAN		*Stantonoceras guadaloupae*	*Marsupites*	*Parapuzosia leptophylla* (Kent, Sussex).
		Mortoniceratan	*Eupachydiscus* sp.		
			Parapuzosia corbarica	(*Uintacrinus*)	
			Mortoniceras texanum	*M. cor-ang.*	*Parapuzosia* spp. (Kent, Dorset, Yorks). *Mortoniceras texanum* (Kent).
			Mortoniceras emscheris		
	CONIACIAN	*Gauthiericeratan*	*Gauthiericeras margae*		
			Prionocycloceras (3) *guyabanum*		
			Barroisiceras nicklesi	*M. cor-test.* (?)	
			Barroisiceras haberfellneri		
			Peroniceras subtricarinatum		
TURONIAN	ANGOUMIAN	*Prionotropidan*	*Pseudojacobites farmeryi*	*Hol. planus* (Chalk Rock)	*Pseudojacobites farmeryi* (Norfolk).
			Hyphantoceras reussianum		*Puzosia* (? *Austiniceras*), *Pseudopuzosia* (7), *Pachydiscus, Prionocyclus, Scaphites, Hyphantoceras, Allocrioceras* (8), *Metaptychoceras* (9), *Cyrtochilus* (Wilts, Cambs).
			Prionocyclus neptuni		
			Coilopoceras requinianum		
			Romaniceras deverianum		*Pachydiscus, Austiniceras* sp. (Kent, etc.), *Romaniceras* (Sussex).
			Romaniceras ornatissimum	*T. lata*	
			Prionotropis carolinus		*Prionotropis woollgari* (Sussex).
	LIGERIAN	*Mammitan*	*Vascoceras* sp.		*Pachydiscus, Austiniceras* spp. (Kent, etc.).
			Mammites nodosoides		*Mammites nodosoides* (Dorset).
			Pseudaspidoceras footeanum	*Rh. cuvieri*	*Metasigaloceras rusticum* (Dorset), *Plesiovascoceras catinum* (Wilts).
			Fagesia superstes		*Fagesia pachydiscoides* (Sussex).
			Metoicoceras whitei		*Metoicoceras whitei, Neocardioceras* (10) (Dorset).
RHOTOMAGIAN			*Metoicoceras pontieri*	*A. plena*	

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[1] The generic names marked with numerals are discussed in the text.

[*To face p. 80.*

Mantell) Woods ("Mollusca of the Chalk Rock": *Quart. Journ. Geol. Soc.*, vol. lii, 1896, p. 84, pl. iii, figs. 9–9*a*). No one will now maintain the generic identity of the Turonian forms with the true Hauterivian *Crioceras*. The new genus belongs neither to Hamitidae nor to Anisoceratidae, but may provisionally be accommodated in Phlycticrioceratidae. *Neancyloceras*, referable, with *Glyptoxoceras*, to Diplomoceratidae, has only superficial resemblance to *Allocrioceras*.

(9) **Metaptychoceras** gen. nov. Genotype *Ptychoceras smithi* Woods (loc. cit., 1896, p. 74, pl. ii, figs. 1–2). This is closer to the Albian *Hemiptychoceras* Spath than to the true Neocomian *Ptychoceras*; and probably stands in the same relationship to the last (Turonian) survivors of Hamitidae as the Campanian *Solenoceras* Conrad does to Diplomoceratidae.

(10) **Neocardioceras** gen. nov. Genotype *Amm. juddi* Barrois and Guerne ("Descript. de quelq. éspèces nouv. de la Craie de l'Est du Bassin de Paris": *Ann. Soc. Géol. Nord.*, vol. v, 1878, p. 46, pl. i, figs. 1–2). An early genus of Prionotropidae, occurring with *Metoicoceras* and resembling *Prionocyclus* Meek, except in its "*Quenstedtoceras*" keel.

Some notes on the nomenclature of a few other Turonian and earlier Cenomanian Chalk ammonites may be acceptable to the general palaeontologist and collector. For example the following forms figured by Sharpe require new names, since they are not identical with the species to which they were referred by that author, and in some cases do not even belong to the same genus. Certain of Sharpe's forms have already been renamed in previous papers[1] but it is hoped that such large genera as, for example, *Schloenbachia*, will soon attract the attention of some worker on the Chalk, enthusiastic enough to undertake the tedious zonal collecting, essential to a successful monographic treatment.

(1) *Schloenbachia* **subvarians,** sp. nov. (= *Amm. varians* Sowerby var. *intermedia* Sharpe non Mantell. Pl. viii, fig. 7). This is more compressed and less distinctly tuberculate than the lectotype of *S. varians* (d'Orbigny, loc. cit., 1841, pl. xcii, figs. 3, 4 only, in Semenow, "Faune Dép. Crét. Mangychlak": *Trav. Soc. Imp. Nat. St. Pétersbourg*, vol. xxviii, livr. 5, 1899, p. 102), or *S. subtuberculata* (Sharpe's fig. 5, pl. viii), discussed by Stieler (Über Gault- und Cenoman Ammon. a.d. Cenoman d. Cap Blanc Nez": *N. Jb. F. Min.*, etc., 1922 (ii), 2, p. 31). The true *S. intermedia* (Mantell) is somewhat intermediate between this and *S.* **glabra** nom. nov. = *Amm. goupilianus* Sharpe (pl. xvii, fig. 5) non *Prohauericeras goupilianum* (d'Orbigny), but the ribbing is still retained.

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[1] In addition to those already quoted: "Up. Cret. Amm. from Pondoland": *Ann. Durban Mus.*, vol. iii, No. 2, 1921, pp. 39–56; "Senon. Amm. Fauna of Pondoland: *Trans. Roy. Soc. S. Afr.*, vol. x, pt. 3, 1922, pp. 113–47; "Cret. Amm. from Angola": *Trans. Roy. Soc. Edinb.*, vol. liii, pt. 1, No. 6, 1922, pp. 91–160; "Up. Alb. Ammon. from Portug. East Afr. With an Appendix on Up. Cret. Amm. from Maputoland": *Ann. Transvaal Mus.*, vol. xi, pt. 3, 1925, pp. 179–200.

(2) *Pachydiscus* **sharpei** nom. nov. (= *Amm. peramplus* Sharpe, pars, non Mantell, pl. x, fig. 1 only). Sharpe's *Amm. lewesiensis* (non Mantell, pl. xxi, fig. 1) is close to the bluntly-ribbed, true *Amm. peramplus* Mantell but, perhaps, not inflated enough, which, however, is largely due to its mediocre state of preservation. The young of the true *P. peramplus* resembles *Amm. prosperianus* d'Orbigny and *Pachydiscus rhodanicus* Roman and Mazeran; the young of *P. sharpei* is closer to *Pachydiscus* **cricki** nom. nov. (= *Amm. peramplus* Sharpe, pars, pl. x, fig. 3 only)), but more compressed. Schlüter's *Amm. peramplus* (loc. cit., pt. ii, 1872, pl. x, figs. 7–13) probably belongs to this species or to *P. sharpei* and not to P. (?) *varu* (Stoliczka) which is perhaps referable to the genus *Nowakites* Spath.

(3) *Acanthoceras* **evolutum** nom. nov. (= *Amm. sussexiensis* Sharpe, non Mantell, pl. xv, fig. 1, *Mus. Pract. Geol.*, No. 7754, Geol. Soc. Coll.). This is more compressed and more evolute, and has more coarsely ornamented inner whorls, than the true *Acanthoceras sussexiense* (Mantell). J. de C. Sowerby's *Amm. rhotomagensis* (non Defrance, *Min. Conchol.*, vol. vi, 1825, pl. DXV, lower fig. only) has resemblance to the rapidly increasing true *Ac. sussexiense*, but at its comparatively small diameter cannot easily be distinguished from *Acanthoceras rhotomagense* (Defrance, in D'Orbigny, loc. cit., 1842, pl. cv, figs. 5, 6) except by its greater whorl-thickness. Schlüter's "*Amm. sussexiensis*" (loc. cit., pt. 1, 1871, p. 15, pl. vii, fig. 3) is different, and a new name, *Acanthoceras* **simulans** nom. nov. is now proposed for it. Sharpe's *Amm. rhotomagensis* (non Defrance, pl. xvi, fig. 1, Mus. Pract. Geol., No. 7756, Geol. Soc. Coll., now renamed *Acanthoceras* **vectense** nom. nov.) is more inflated and more obliquely and closely ribbed than typical examples of Defrance's species, and does not change its ornamentation at the end as does *Ac. sussexiense.* Since all authors are agreed that Sharpe's *Amm. cenomanensis* (pl. xvii, fig. 1) does not conform to d'Archiac's type, it is necessary to rename this also; and I should like to propose for it the new name *Acanthoceras* **sherborni** n.n., in recognition of Mr. C. D. Sherborn's valuable researches on the Chalk as well as his constant friendly advice in bibliographical matters.

(4) *Protacanthoceras* **jukes-brownei** nom. nov. (= *Amm. hippocastanum* Sharpe, pars, non Sowerby, pl. xvii, fig. 2 only). This is distinguished from the true *Protacanthoceras hippocastanum* (Sowerby) by being less inflated and less coarsely tuberculate.

(5) *Mantelliceras* **cantianum** nom. nov. (= *Amm. navicularis* Sharpe, pars, non Mantell, pl. xviii, fig. 1 [lectotype] and 2). This is a true *Mantelliceras*, differing from the earlier and smaller *M. mantelli* Sowerby sp. (including Sharpe's pl. xviii, fig. 7) and *M. tuberculatum* Mantell sp. (see Sharpe's fig. 6 of the same plate) merely in more robust, coarse, ornamentation. Sharpe confused examples of two separate stocks and misled Hyatt ("Pseudoceratites of the Cretaceous": *Bull. U.S. Geol. Surv.*, vol. xliv, 1903, p. 113)

as well as the writer (loc. cit., Zululand, 1921, p. 315). The genus *Calycoceras*, unfortunately, cannot now be emended so as to cover what the writer called *Eucalycoceras* (including *E.* **subgentoni** nom. nov. = *Amm. navicularis* Sharpe, pars, non Mantell, pl. xviii, fig. 3 only), and in its original sense *Calycoceras* is synonymous with *Mantelliceras*. Mantell's *Amm. navicularis*, to judge by examples in a better state of preservation, may be identical with *Amm. laxicosta* Lamarck (including *Amm. navicularis* d'Orbigny, loc. cit., pl. ciii) and Sowerby's *Amm. navicularis* (loc. cit., pl. DLV, fig. 2) probably belongs to the same stock. There is at least one other, closely costate, unnamed, species of the same group; and since it is also impossible to use the generic name *Calycoceras* for this stock, the new name **Metacalycoceras** gen. nov. is suggested, type to be the example figured by d'Orbigny.

The Age of the Duruma Sandstone, East Africa.

By J. W. GREGORY, D.Sc., F.R.S.

WEST of the marine Jurassic rocks near Mombasa the Uganda Railway traverses for 46 miles a belt of sandstones and shales which are grouped together as the Duruma Sandstone.[1] The few fossils hitherto obtained from this series have not given any definite evidence as to its age, which is, however, shown by the relations of the sandstones to the Kambe Limestone to be pre-Bathonian. The Mazeras Sandstone; one of the upper members, contains many trunks of *Dadoxylon*, the age of which, according to Professor Seward, may be anything from Trias to Kainozoic. An *Estheriella* and some plants were found in the Maji ya Chumvi beds by Maufe and have been regarded as either Permian or Triassic. The lowest division, the Taru Grit, has not yet yielded any certain fossil, but it has been regarded as continuous with the shales in the Sabaki Valley, which yielded the Permian mollusc, *Paleanodonta fischeri*, and with the plant bearing Tanga beds in the north-eastern corner of Tanganyika Territory. A bore in quest of water was made near Samburu Station to the depth of 527 feet in the Taru Grits. The cores are preserved by the Uganda Railway at Nairobi, and Mr. David Harris recently re-examined them and made the useful discovery of two fragments of fossil plants. They have been kindly sent to me by Dr. A. W. Rogers and examined by Professor A. C. Seward. He identifies them as a *Voltzia* and an *Ullmania*. For the drawings, Fig. 1, I am indebted to Mr. L. D. Currie. Both fossils are specifically indeterminable, but Professor Seward states that they certainly belong to the flora collected by Dr. Teale in the Tanga beds, which was described in 1922.[1] Professor Seward assigns that flora to an age between the Upper Permian and the Rhaetic, and seems inclined to regard it as probably Trias.

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[1] The succession of the beds has been described by Maufe, 1908, *Rep. Geol. E.A. Protectorate*, Col. Rep. No. 45, Cd. 3828, and GEOL. MAG., 1915, pp. 274–7, and Gregory, *Rift Valleys and Geology of East Africa*, 1921, pp. 46–58.

The Taru Grits, according to Maufe, are at least 5,000 feet in thickness, and this new evidence suggests their subdivision into a lower series, which may retain the name, and an upper series—the Samburu Grits—which are exposed at Samburu and were traversed by the bore. Mr. Harris tells me that the two fossils came from the depth of 515 feet, so that they were only 12 feet above the lower end of the bore. The restricted Taru Grit may be Permian, as some of its shales resemble those which yielded the *Paleanodonta* on the Sabaki ; but as that fossil has not yet been found along the line of the Uganda Railway, the Sabaki beds may not extend as far south. The Taru Grits are probably the northern extension of the Lower Tanga beds, as suggested by Dr. Teale (op. cit., p. 387). The Samburu Grits with the two fossils correspond to the plant-bearing Middle Tanga beds. The middle division of the Duruma Sandstone, viz. the Maji ya Chumvi beds, and Mariakani Sandstone, correspond to the Upper Tanga beds. The Mazeras

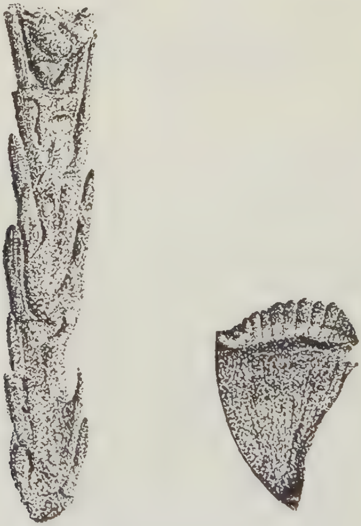

FIG. 1.—Fossil plant from the Samburu Grits, Duruma Sandstone, from a bore near Samburu station, Kenya Colony. *a. Ullmannia* sp., *b. Voltzia* sp. Both × 2 dia. Identified by Prof. Seward, drawn by L. D. Currie. Hunterian Museum, University, Glasgow (Nos. 1030, 1031).

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[1] A. C. Seward, "On a Small Collection of Fossil Plants from the Tanganyika Territory," with notes on the Tanga beds by Dr. E. O. Teale: GEOL. MAG., 1922, pp. 385–92, 1 pl.

Sandstone with the Dadoxylon forest, and the Shimba Grits, may be younger than any of the Tanga beds; for Dr. Teale does not record *Dadoxylon* in the Tanga series, which may be below its level.

Whether any of these beds belong to the Rhaetic is uncertain. The Shimba Grit is separated by such a strong unconformity from the marine Bathonian beds, the Kambe Limestone, that there is as yet no reason to alter the reference of the whole of the upper part of the Duruma Sandstone to the Trias. The stratigraphical evidence only proves its age as pre-Bathonian.

On *Caenophyllum*, a remarkable New Genus of Carboniferous Coral.

By Arthur E. Clark, M.A., Trinity College, Cambridge.

I. Introduction.
II. Caenophyllum gen. nov.
III. Caenophyllum varians sp. nov.

I. Introduction.

INCLUDED in a large assemblage of corals from the Lower Carboniferous Shales—referred to a Z horizon—overlying the Lower Carboniferous Sandstone anticline (K) on the north coast of Co. Sligo is a remarkable new genus—*Caenophyllum*—which forms the subject of this paper. *Caenophyllum* gen. nov. claims distinction in showing a very unusual life-history—quite unlike that of any known coral; and forms a very interesting example of abnormal coral ontogeny. The shales form cliffs at Pollarone, near Dromore West, Co. Sligo, and vary in height from 30 to 50 feet. They are cut off by the rising tide, and consequently have hitherto been neglected; but are of great importance in zonal work, as they contain a rich coral and Bryozoan fauna and thus form a starting point for zonal investigation.

The stratigraphical position of these shales was discussed in a previous paper.[1]

I wish to thank Dr. W. D. Lang for valuable assistance and advice.

II. Caenophyllum gen. nov.

(καινος, " new "; φύλλον " a leaf ", i.e. " a septum ".)

Diagnosis.—The corallum is simple, and slightly cornute. The primary development is substantially similar to that of a normal rugose coral, but later development is quite abnormal. A ring of stereomed dissepiments appears at an early stage. It quickly disappears on the counter side, and moves centrally on the cardinal side until the inner ends of the septa of that side are connected.

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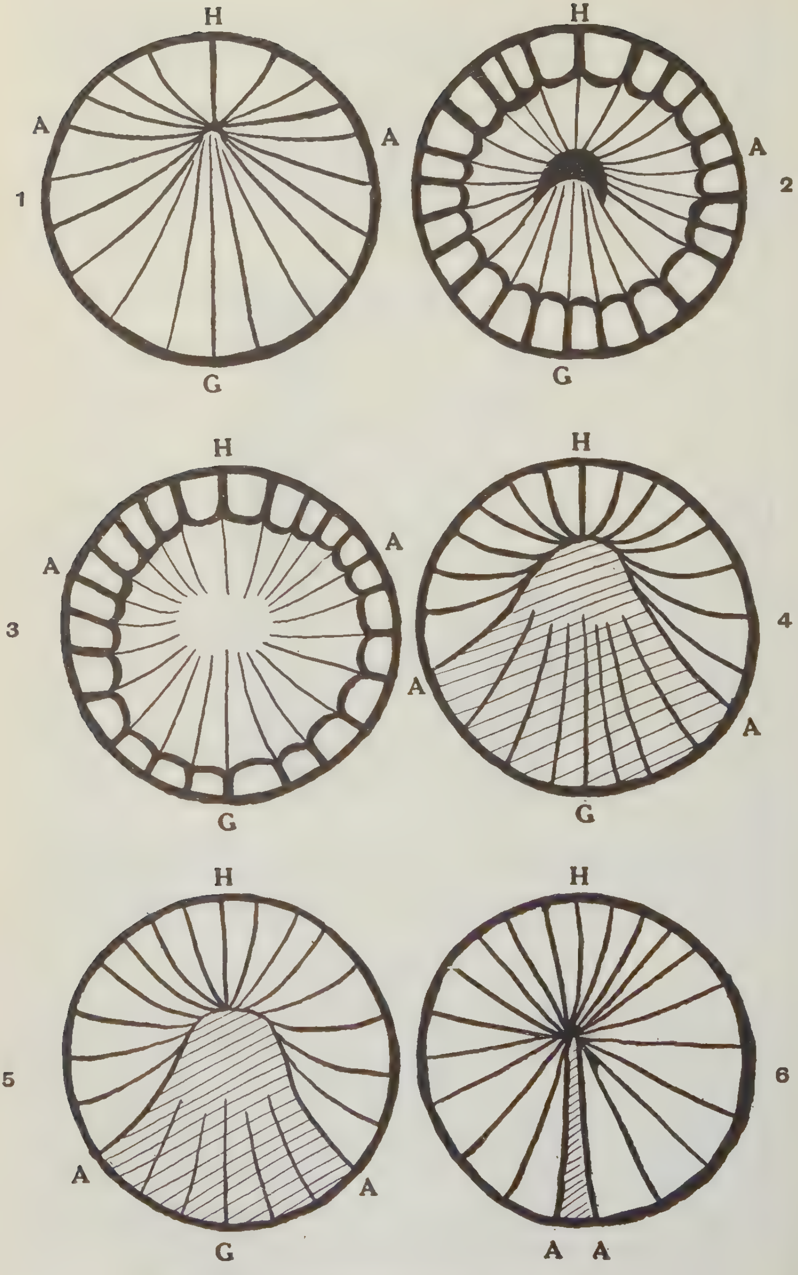
[1] A. E. Clark, " On *Heptaphyllum*, a New Genus of Carboniferous Coral ": Geol. Mag., Vol. LXI, 1924, p. 416.



FIGS. 1-6.—*Caenophyllum varians* gen. et sp. nov.

A large counter "pseudofossula" is thus formed, in which the septa of the counter side lie loose and disconnected, and later disappear. As these septa disappear *new* septa are inserted on the cardinal side—next to the cardinal septum—and the alar septa move towards the counter side, thus obliterating the "pseudofossula", until a radial arrangement is assumed. The cardinal fossula is conspicuous in early stages of development, but tends to disappear in later stages.

Distribution.—Z; Pollarone cliffs, Dromore West, Co. Sligo.

Genotype.—*Caenophyllum varians* sp. nov.

Remarks.—The generic name is derived from the fact that new septa are inserted during the life-hisrory as the septa of the counter side vanish; hence "*Caenophyllum*" = "new septum". A number of specimens were serially cut and carefully ground down and showed substantially the same ontogenetic stages.

III. CAENOPHYLLUM VARIANS sp. nov.

Description.—(1) External morphology: The *corallum* is gently curved at the tip, and expands rapidly in the calicinal region. Average dimensions: length of corallum, 2 cm.; diameter of calcinal rim, 1 cm. There is a broad basis of attachment. The *epitheca* may have well-marked longitudinal ribbing, or may be annulate. Growth is regular, and no constrictions occur, nor interruptions in the continuity of the epitheca.

The *calice* is shallow, showing the septa well developed, strong, radially arranged, usually reaching the centre of the calicinal floor and without any conspicuous fossula.

The cardinal fossula is inconspicuous and the cardinal septum does not differ from the surrounding metasepta.

There is no true counter-septum in the adult. The "pseudofossula" on the counter-side is formed by the closing in of the septa originally confined to the cardinal side, after the disappearance of the septa of the counter side. This is shown by serial transverse sections (Figs. 1–6).

(2) Internal morphology: The earliest stage observed showed a well-developed but very short cardinal fossula, and an inconspicuous counter fossula. The cardinal septum and metasepta of the cardinal sectors are all very short, while the counter and counter-lateral primaries and associated metasepta are long and tapering. The alar septa are almost at right angles to the cardinal septum, as in *Heptaphyllum*, and the counter-laterals lie close to the counter septum (Fig. 1).

The next section shows a marked concentric structure: a ring of stereomed dissepiments is developed which connects all the septa near their outer ends as shown in Fig. 2. The inner ends of all except five septa on the counter side meet in a crescentic mass of stereoplasm in the centre of the corallum. The middle parts of the septa, inside the ring of dissepiments, are thin and fragile, while the outer parts, outside the stereomed dissepiments, are considerably thickened by stereoplasm. The septa of the cardinal side have become longer and those of the counter side correspondingly shorter. The section at this stage shows a marked resemblance to a wheel: the central stereoplasmic mass representing the axle, the thin delicate septa as the spokes, and the stereomed peripheral structure as the rim. The symmetry is broken by the cardinal fossula, which, however, is decreasing in size as growth proceeds; by the crescentic shape of the "axle"; and by the fact that some of the septa on the counter side lie loose and disconnected at their inner ends.

In the next section (Fig. 3) the central stereoplasmic mass has disappeared, and the septa fail to reach the centre of the corallum, leaving a small central tabular space. The outer ends of the septa are still thickened by stereoplasm, and the ring of stereomed dissepiments remains the same.

In the next section the dissepiments change their positions, those on the cardinal side move centrally, while those of the counter side tend to disappear, until the septa on the cardinal side are connected at their inner ends, and those of the counter side lie quite loose and disconnected in the very large "pseudofossula" thus formed. This arrangement is shown in Fig. 4. The septa of the counter side have become reduced in number, while those on the cardinal side have correspondingly increased in number by the insertion of *new* septa next to the cardinal septum.

The next stage shows a further reducton in the number of septa on the counter side, thus reducing the size of the pseudofossula, which is bounded by the alar septa, which are encroaching on the counter side as the septa of that side vanish, and new septa are inserted on the cardinal side. There are five septa on the counter side at this stage—the original counter septum is in the middle, bounded by the counter-lateral primaries, with a single metaseptum on each side. This stage is shown in Fig. 5.

In the final stage (Fig. 6) the original septa of the counter side have all vanished, and the series belonging to the cardinal side, which have still further increased in number, now extend along the whole circumference. The pseudofossula is now very small and slender. The septa are irregularly thickened, and the general arrangement is radial, without any conspicuous fossula, suggesting a Densiphylloid structure.

Distribution.—Z; Pollarone cliffs, Co. Sligo.

Type-specimen.—Holotype in the Sedgwick Museum, Cambridge. Material also in the British Museum (Natural History).

Ontogeny.—The extraordinary changes of structure shown by the successive stages of this coral have been already pointed out, and are unlike anything hitherto described.

The primary stages of development are obscured by the large size of the basis of attachment, but the earliest stage observed suggest that the primary development is not quite normal. In a normal rugose coral the primary septa on the cardinal side are developed before those on the counter side, and are therefore longer. In this coral the cardinal and alar septa are much shorter than the counter and counter-lateral primaries. Again, the alar septa are at right angles to the cardinal septum, which is unusual.

REVIEWS.

TEXT-BOOK OF PALAEONTOLOGY. By KARL A. VON ZITTEL. Vol. III: MAMMALIA. Revised by MAX SCHLOSSER and translated under the direction of C. R. EASTMAN. Translation revised, with additions, by Sir A. SMITH WOODWARD. pp. viii + 316; 374 illustrations. London: Macmillan and Co., 1925. Price 25*s*. net.

IT is now more than twenty years since Zittel's classical work was first published, and during the interval that has since passed the advances made in the study of mammalian palaeontology have been very great. The present version is a translation of the third German edition, which was twice revised by the original author, and afterwards further enlarged by Dr. Schlosser, of Munich. As with the two earlier volumes of the work, the editorship of the English translation was entrusted to Charles Eastman, but the present part dealing with the Mammalia, was left unfinished at that palaeontologist's death in 1918, although it was nearly all in type. The actual translation was done by Miss Engler, of New York, and Miss Bush, of New Haven, assisted by Professor Loomis, of Amherst College. The time that has elapsed since Dr. Eastman's death has necessitated a further revision, and it is fortunate that this was entrusted to Sir Arthur Smith Woodward, who has extended the bibliographies and included accounts of the more important recent researches. As evidence of the thorough manner in which the English editor has performed his task we may cite the references to the memoirs of Forster Cooper on *Baluchitherium* and *Paraceratherium*, Osborn's work on the former genus, and Abel's memoir on *Chalicotherium*, as well as the account given of Sir Arthur's own work on *Eoanthropus* from the Pleistocene gravel of Piltdown. The important investigations of Otto Zdansky (1924) on the mammals of the Hipparion beds of China, which supply evidence as to the contemporaneity of the Tertiary succession in different parts of the world and throw light on the phylogeny of the hyaena, the badger, and various other mammals, were presumably published too late for inclusion in this textbook. It is safe to say, however, that this edition of " Zittel ", composite though it is in authorship, constitutes the best and completest account of the evolution of the different mammalian groups that has yet been published. Every known genus which had been found fossil appears to be included and there is a wealth of detail in the descriptions which only in a few instances could profitably have been extended. Many of the illustrations are new, and those which are borrowed are well chosen, being usually from the original authorities.

In a work of such excellence there is little room for criticism. Nevertheless we must take exception to certain features in the classification, which is apt to be on the conservative side. The grouping of the Monotremata and Marsupialia into one sub-class (the Eplacentalia) in contrast to the rest of the mammals is hardly justified in view of what is now known of the embryology and physiology of these animals. The oviparous habit of the monotremes, together with the correlated structure of the reproductive organs and the more primitive type of mammary glands, not to mention the single cloacal aperture, are indicative of a wider gap between this group and the marsupials than that between the latter and the higher animals. Moreover, the use of the term Eplacentalia for the marsupials is no longer legitimate in view of the discovery of a definite allantoic placenta in more than one genus of that order.

The retention of the order "Subungulata" (p. 246) for the somewhat heterogeneous assemblage of Hyracoidea, Proboscidea, Sirenia, and Embrithopoda contained therein is also hardly justified. This is indicated by the definition at the beginning: "*Usually* large, plantigrade *or* digitigrade herbivores *or* animals adapted for an aquatic life, having *originally* a complete brachydont-bunodont dentition. A pair of incisors are enlarged in early forms, often developing into tusks, the remaining incisors and canines reduced, entirely lacking or gradually passing into one another. . . . Bones of carpus and tarsus slightly alternating *or* serial; centrale *often* present. Extremities specialized in *various* ways, and in aquatic forms the posterior pair is totally reduced. . . . Uterus bicornuate, placenta zonal, *usually* deciduous." (The italics are ours.) Indeed there is hardly a character cited which is descriptive of all the forms contained in this group, and which is not at the same time applicable also to many other animals outside the group. That the various "sub-ungulate" genera possess some resemblances is undoubted, but the degrees of affinity are very problematic. The lack of the primitive feature of the entepicondylar foramen of the humerus does not seem convincing evidence that they arose from an ancestor common only to themselves among the known families of mammalia. That *Moeritherium* approaches the primitive Proboscidea and Sirenia must be admitted, and the author is probably right in postulating a relationship of all the four groups to the Condylarthra. But the latter are included as a sub-order of the Ungulata. We venture to think that it would have been better to have arranged the sub-ungulate groups also as sub-orders or orders of the ungulates, as is done by Abel.

On p. 157 the "division of the domestic horses into numerous races" is ascribed "to the training and domestication of the Old

World wild horse ". This statement ignores the work of Ewart and others pointing to the multiple origin of the modern varieties, but Ewart's papers are duly referred to in a footnote. There is no mention, however, of the somewhat similar views which have been put forward in regard to the origin of the domestic breeds of cattle and sheep. On p. 201 it is stated (no doubt correctly) that in the so-called Irish elk the females were hornless. From this the uninformed might infer that with the other genera mentioned on the same page (e.g. *Dama*), the females were horned, since the contrary is not stated. On p. 219 "zebra" is presumably a misprint for "zebu". These, however, are details of small importance.

The book concludes with a section entitled " Observations on the geological development, origin, and distribution of mammals", and this makes fascinating reading. It is shown that the northern hemisphere is of far greater importance as a centre for the origin of the mammals than any other part of the earth, Africa being a real centre only during the Eocene and then only for a few limited groups. But the most remarkable conclusions are those which the author draws about the fauna of Australia. It has been usual to regard Australian mammals as the descendants of primitive monotreme or marsupial genera which became separated from the rest of the world fauna in Mesozoic times when these animals were the dominant type of the class, and that in a condition of geographical isolation they were able to develop undisturbed into numerous genera of diversified habits of life. In view, however, of recent discoveries in the Tertiary beds of Patagonia it is suggested that the ancestral forms arose in South America and that their derivatives spread to Australia in Tertiary times. This view postulates an incomplete bridge of land, " for otherwise the Edentata, Litopterna, and Notoungulata would also have reached Australia." It takes no account of the rodents, but it is perhaps supposed that this order did not reach South America before the southern land connexion with Australia had subsided. It appears also that palaeontologists have not yet considered the possible bearing of the Wegener theory of continental drift on the distribution of land animals. The whole matter is still extremely problematical and it is to be hoped that Australian and South American geologists will take it up further.

F. H. A. M.

THE AVERAGE COMPOSITION OF THE EARTH'S CRUST IN FINLAND.

By J. J. SEDERHOLM. *Bull. Comm. Géol. Finl.*, No. 70, 1925.

THE author argues, as Mennell and Daly have done before, that, in computing the average composition of the crust from tables of rock-analyses, the purely statistical method followed by Clarke and others is open to serious objections, and that a truer result will be found by taking a duly *weighted* average of the more important and widespread rock-types. He has applied this method to the Finnish area, an extensive and deeply eroded continental tract composed essentially of pre-Cambrian rocks. The average so obtained has the composition of a granodiorite, with a silica-percentage 67·45, a much more acid rock than the diorite of Clarke and Washington.

The pre-Cambrian plutonic rocks are everywhere predominantly granitic, and the author surmises that this would hold good of later plutonic rocks also, if erosion had laid bare the granites which are presumed to underlie the younger mountain-chains. Among effusive rocks of all ages, on the other hand, basalts seem to preponderate. Either they have been derived by differentiation from more acid magmas, or effusive rocks are drawn from a more basic shell underlying the granitic shell, and the author believes both explanations to be true for different cases. He repudiates Bowen's theory of the derivation of acid rocks by differentiation from a primitive basic magma, since on that supposition gabbros ought to bulk much more largely than granites. This argument seems to assume that basic magmas rise into the shallower levels of the crust as easily as acid. If the supposed differentiation proceeds in deep-seated reservoirs (which, however, is no part of Bowen's hypothesis), it may well be that great bodies of basic rock actually exist at levels which are not often reached by erosion. In that case, too, the average composition of a ten-mile crust may be considerably less acid than that computed from rocks exposed at the surface.

A. H.

Outlines of the Mineral and Water Power Resources of the Gold Coast, B.W.A., with Hints on Prospecting. By A. E. Kitson. Gold Coast Geological Survey. Bull. No. 1, pp. 1–56. Plates 13, including 1 map.

THE professed object of this Bulletin is to outline the three chief exploited industries of the Gold Coast, viz., gold, manganese and diamonds and the potential stores of bauxite. Such being the case, geology is touched on but lightly, a matter for some regret, as but comparatively little has been published. The pre-Cambrian Birrim Series, overlain probably unconformably by the Tarkwa Series, are in many places greatly metamorphosed by a number of intrusions, ranging from aplites to pyroxenites. The later Palæozoic is represented by Middle Devonian and Lower Carboniferous followed in western Apollonia by Jurassic and Cretaceous beds noteworthy for their oil seepages.

All the localities where these occur are near the coast and are stated to be "portions of down-faulted blocks".

Unfossiliferous beds associated with them are considered to be probably the Volta or Kwahu Series, doubtfully placed in the Carboniferous and found in typical development between Ashanti and the Northern Territories.

This account occupies barely three pages, the remainder being devoted to mineral deposits, water-power, and the like. It appears that Nature has given with lavish hand to the Gold Coast, for of the three sedimentary series mentioned, each one has its attendant deposit of an important mineral.

Bauxite caps the upturned ends of the Birrim phyllites in Sefwi and Ashanti; this Series provides also the manganese of the Colony contained not only in these phyllites, but in a spessartite-quartz-rock which the author compares with the gondite of India. Segregation deposits from these are the material now worked on a large scale, a value of more than a million sterling having been obtained from Insuta in the Colony for the eight years ending in 1924.

Gold is found in lodes in the Tarkwa Series, or as detrital deposits, and bauxite is again associated with the Kwahu Beds occurring on the highest hills.

Of the bauxite, and indeed of the other minerals of value, Mr. Kitson gives full details. The figures of material available are very high; the quantity of massive bauxite, for instance, occurring on six hills near Sefwi Bekwai is conservatively estimated as over 22 million tons, with a probable aluminium content of about 6 million tons, the total deposits of good bauxite in the Sefwi district being upwards of 50 million tons. The Gold Coast is fortunate.

J. P.

GEOLOGIE AFRIKAS. By Dr. E. KRENKEL. Vol. i, pp. x + 461, with 21 plates and 105 figures. Berlin: Borntraeger, 1925.

THIS work forms part of a projected great series of monographs, to be entitled *Geologie der Erde.* This seems a comprehensive title, and it would appear as if the work should cover much the same ground as the well-known *Handbuch der regionalen Geologie.* However, it is explained in a prefatory note, printed on the inside of the cover of this book, that the series is intended to have a wider scope, dealing not only with stratigraphy but also with geophysics and geochemistry in their bearing on geological structures and events, as well as other cognate topics.

The present volume contains a discussion of the physiography of Africa as a whole, and of the broad lines of its geological structure, the surrounding islands being also included. Then the continent is divided up into main regions (Grossregionen) to be studied in detail. For some of these the limits are stretched rather widely, as it would seem; at any rate it is news to the present reviewer that Mesopotamia is in Africa. The regions included in the present volume are Syrabia, Egynubia, Abessomalia (the meanings of these telescoped names hardly need explanation), East Africa, and the islands of the Indian Ocean. The second volume is to begin with South Africa and will include all the western half of the continent.

In places the style is rather unnecessarily difficult, as the author prefers to begin sentences with the accusative case, and he uses a good many rather uncommon words, though most of his sentences are quite short. In addition to personal knowledge, the literature has evidently been very thoroughly ransacked, and there are well-selected bibliographies for each chapter. From these purely palaeontological publications have been deliberately omitted. Some of the illustrations of scenery in the plates are very beautiful, and an extraordinarily effective use is made of air-photographs taken from great heights. One of the Jordan valley in plate iv is particularly striking, as is also a view of the country between Jerusalem and the Jordan on plate vi.

REPORTS AND PROCEEDINGS.

GEOLOGISTS' ASSOCIATION.

8th January, 1926.

" A Correlation of the British Permo-Triassic Rocks." Part I. North England, Scotland, and Ireland. By R. L. Sherlock, D.Sc., A.R.C.Sc., F.G.S.

The main purpose of this paper is to show that Keuper, Bunter, and Permian, as used in Britain, are names having a lithological meaning and are not time-divisions, although it is true that the types of rock associated with the names do tend to occur in a certain sequence; e.g. marl at the top and magnesian limestone at the bottom. In Part I the Permo-Triassic deposits in the six northern counties of England, together with Nottinghamshire, Scotland, Ireland, and the Isle of Man, are considered.

The Permo-Trias has always been classified from the base upwards. As the base rests with a great unconformity on older rocks and a very uneven surface, this leads to a wrong correlation. In this paper beds are correlated by reference to certain datum-planes, some of which are beds of salt, gypsum, and anhydrite, which can be traced for considerable distances; the chief datum-plane being the base of the Rhaetic Beds. It is shown, e.g. that " Bunter " strata of one region is the time-equivalent of " Permian " strata of another. A conclusion is that there is no " Permian " System in the area considered, although that area contains the only fossiliferous so-called " Permian " rocks of this country.

The mode of origin of the strata and the geography of the area in Permo-Triassic times are considered.

22nd January, 1926.

The following papers were read in abstract, opportunities being afforded for their discussion :—

" On Outliers of Lenham Beds at Sanderstead, Surrey." By F. Gossling, B.Sc., F.G.S., and S. W. Wooldridge, M.Sc., F.G.S. Weald Research Committee Communication.

This paper records the discovery of two outliers of Lenham Beds at Sanderstead and Selsdon Hill respectively. They may ultimately prove to be continuous, but the evidence at present available renders this doubtful. The beds range in height from 440 feet to 560 feet O.D., and their lithological and petrographical features prove to be comparable in all respects with those of the beds at Headley, Chipstead, Shooters Hill, etc. In the light of the new evidence thus afforded, attention is drawn to certain general considerations bearing upon the date and magnitude of the final uplift of the Weald and the varying physiographic form presented by the dip-slope of the North Downs.

" Some Chalk Sections in N.E. Surrey." By A. G. Davis.

" Glacial Features in a New Exposure at Finchley." By N. L. Silvester, M.Sc., F.R.Met.Soc.

" Some Recent Sections in the Glacial Deposits of the Finchley Plateau." By H. W. Cornes, B.Sc., F.G.S.

(This paper is based on observations made for the Temporary Sections Committee.)

EDINBURGH GEOLOGICAL SOCIETY.

16*th December*, 1925.

(1) " The Intrusive Igneous Rocks of the Dundee District." By John W. Harris, B.Sc.

The igneous intrusions in the near vicinity of Dundee occur in the form of thick sheets, boss-shaped and laccolithic masses, and dykes and veins. The igneous rocks include dolerites containing rhombic and monoclinic pyroxenes, plagiophyres, quartz-bearing pyroxene-dolerite, biotite-porphyrite, and microgranite. They appear to follow this order in intrusion : for example, the plagiophyres are intrusive in the dolerites with rhombic and monoclinic pyroxenes, while the biotite-porphyrite and microgranite are seen to cut the quartz-dolerite, with the microgranite also intrusive in the porphyrite. There is, therefore, a petrographic sequence from a basic, through less basic, to an acid type.

These igneous rocks are intrusive in Lower Old Red Sandstone sediments, and, although their definite age is somewhat uncertain, the balance of probability is in favour of a Devonian age for these intrusions.

(2) " A Lava at the Base of the Downtonian, Stonehaven." By Arthur G. Hutchison, B.Sc., Student, Geology Dept., University of Aberdeen.

A certain bed in the breccias of the basement member of the Kincardineshire Downtonian series has the field characters of a contemporaneous extrusive rock, and the micro-structure of a weathered and devitrified rhyolite or acid andesite.

The rock is of interest inasmuch as it indicates that volcanic activity began in the schist country to the north of the Highland Fault very early in Downtonian times.

13*th January*, 1926.

"Pilandsberg, an African Ring Complex." By Professor S. J. Shand, D.Sc., F.G.S., University of Stellenbosch, South Africa.

Pilandsberg is a circular group of hills, having an area of about 200 square miles, which rises sharply out of the flat norite country of the Western Transvaal. It is formed by an overlying series of alkaline lavas, with tuffs and coarse breccias underlaid and invaded by nepheline-syenites and felspar-syenites arranged in concentric rings. Between the central plug, which consists of syenite with altered nepheline, and the outer ring of felspathic syenite, there are four rings of syenitic rocks containing fresh nepheline. All of these are products of one magma, and all were intruded very nearly at the same time. It is not directly clear that central subsidence was the cause of the ring structure, but, wherever the dip of the tuff beds can be ascertained, it is directed inwards. Pilandsberg contains a larger mass of nepheline rocks than any other region that has yet been mapped in detail.

CORRESPONDENCE.

OOLITE, PISOLITE, AND TOROLITE.

Sir,—For some time past we have felt the need of a name to describe rocks consisting of pillow-like concretionary masses showing marked concentric structure and which differ from oolites and pisolites only in matter of size. After considerable hesitation we venture to suggest "torolite" and the corresponding adjective "torolitic", from the well-known Latin word "*torus*", a pillow. Unfortunately, "oolite" and "pisolite" are both Greek derivatives, but we have searched in vain for a suitable term from the Greek, and in defence of "torolite" we note that *torus* is connected with the same root as Gk. *στορέννυμι*.

The term torolite is thus proposed for a rock consisting of pillow-shaped concretions, exactly comparable with the grains of oolites and pisolites in structure and origin and differing only in being larger. The concretions may also occur isolated. The iron ores in the Irrawaddian sands, formerly worked in Central Burma, and at present being described by one of us in a paper on "The Extinct Iron Industry near Mount Popa, Upper Burma", are mainly torolites.

H. L. Chhibber.
L. Dudley Stamp.

University of Rangoon.
14th December, 1925.